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PROJECT GLOW. SYSTEM NO. II

June 1967

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OPTICAL GROUP   NORWALK, CONNECTICUT

ENGINEERING REPORT NO. 8837

PROJECT GLOW
SYSTEM NO. II
FINAL REPORT

DATE: June 1967

Details of illustrations in this document may be better studied on microfiche

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U.S. ARMY MISSILE COMMAND
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SUMMARY

This document represents the Final Report on GLOW System II and includes the installation and integration of the System at Kwajalein Test Site, Kwajalein, Marshall Trust Territory.

Salient characteristics of prime equipment are described in detail; a complete bibliography, encompasses all major reports and study phases of the GLOW effort; and a list of abbreviations that occur throughout the report is included.

Illustrations are used freely to support the text and bring the GLOW System into sharper focus.

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INTRODUCTION

On March 26, 1963, The Perkin-Elmer Corporation, Electro-Optical Division, Norwalk, Connecticut, received a contract, No. DA-19-020-AMC-0144(Z), U.S. Army Missile Command, Redstone Arsenal, Huntsville, Alabama, for a two months' study program to establish parameters, block diagrams, and specifications for the Optical Reentry Instrumentation System for Project GLOW.

The overall program objectives were:

1. Determination of absolute spectral radiation emitted by various reentry vehicles of various configurations, compositions, and trajectories.

2. Continuation and extension of the measurements leading to recognition of optical reentry signatures needed in the development of detection and discrimination theory, sensors, and systems.

3. Advancement in methods and techniques for interpretation of radiometric measurements.

4. Evaluation of the effectiveness of optical penetration aids.

5. To provide an accurate tracking platform for testing and evaluation of experimental optical instrumentation.

The study program for GLOW resulted in Engineering Report No. 7387, "Study Report for WSMR Optical Reentry Instrumentation System - Project GLOW", dated 15 July 1963.

Contract No. DA-19-020-AMC-0265(Z) provided for the design and fabrication of two (2) GLOW systems.

This program culminated in the installation and integration of one (1) system at the White Sands Missile Range, New Mexico, Contract No. DA-19-020-AMC-11992(Z), and one (1) at Kwajalein Test Site, Marshall Trust Territory, Contract No. DA-19-020-AMC-0265(Z).

The completed system involved studies and solutions of environmental factors and sites, interfacing of newly-designed components and government furnished equipment and facilities, and transportation preparation to the requested installation sites.

Furthermore, it involved the human engineering factors of specifying consoles, displays, and controls that would promote rapid and correct decisions by the operating crew during critical reentry periods.

SECTION I

SYSTEM DESCRIPTION

1.1. OVERALL DESCRIPTION

The GLOW Optical Reentry Instrumentation System (figure 1-1) is designed to obtain data on the absolute spectral emissions of reentry bodies of various configurations, compositions, and trajectories.

The GLOW system, which comprises data-gathering and proeessing equipment, provides a high degree of aecuracy, flexibility, and mobility.

The major units (figure 1-2) comprising the GLOW system are: a modified Nike-Ajax antenna pedestal equipped with optical data-gathering instruments; a 34-foot semi-trailer instrumentation van containing an operator's console, instrument controls and digital data processing and recording equipment; a B-50 manually operated sighting station; and a computer facility enclosed within a shielded sereen room.

In addition, the GLOW system includes a 60 to 400 eyele frequeney converter, an optieal calibration faeility, and a 28-foot refurbished utility van containing dark room facilities, storage, and work areas.

The heart of the GLOW system is the modified Nike-Ajax radar antenna pedestal and its associated servo system which supports and points all the data-gathering instruments. The modified pedestal (referred to as GLOW mount) can receive its pointing commands from various remote or on-site devices, such as range radar, infrared or visible trackers, television trackers, a stiff stick sided tracking system, manned sighting stations and by the System's computer facility. The GLOW mount contains a vidicon television camera for visual observation of the reentry vehicle (R/V), two dual channel radiometers for nighttime reentry measurements, and a 35mm boresight camera for photography of the R/V. The GLOW mount is protected from the environment by a 16-foot diameter Astrodome. (See figure 1-2.)

Figure 1-1. GLOW System Installation - Kwajalein Test Site

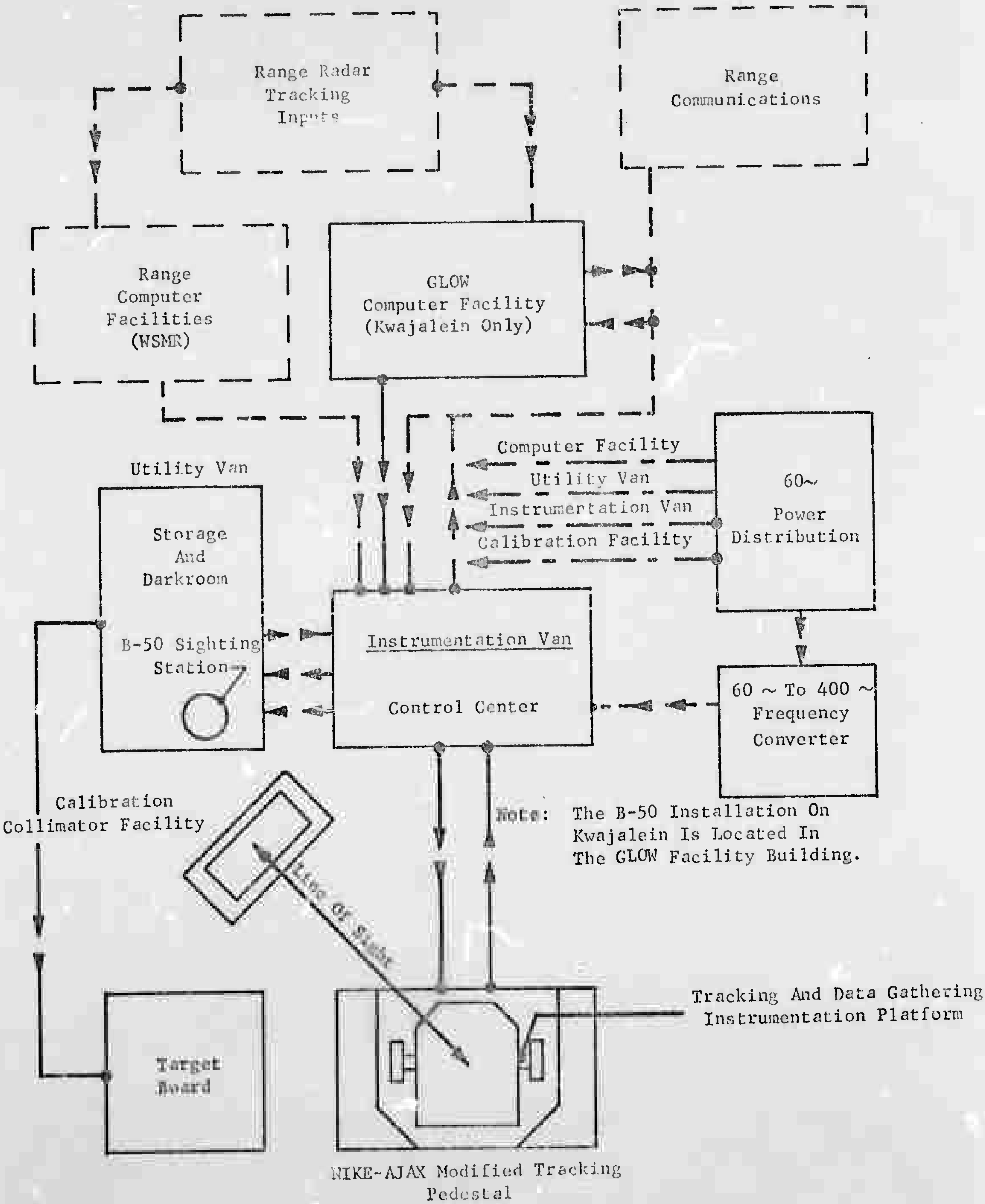


Figure 1-2. GLOW System Assembly

The Astrodome contains a hydraulic servo system and is capable of maintaining orientation with the pedestal azimuth rotation.

The control center of the GLOW system is the 34-foot long instrumentation van. The operator's station, instrument control equipment, pedestal servo system, data processing and recording equipment, and the site's electrical distribution system are all located in the instrument van.

The GLOW mount, the 400 cps frequency converter, and the utility van are connected to the instrument van by cables which are shielded to reduce radio frequency interference (RFI). All input power lines to the instrumentation van contain RFI filters. Junction boxes, connector panels, and raceways are provided under removable sections of the van floor for the distribution of electrical signals and power to the instrument racks and out going cables. The instrumentation van which is shielded against RFI also includes a heater/air-conditioner unit.

The B-50 manual sighting station consists of a modified, manually operated, fire control, altitude azimuth mount.

Two sets of 1:1 and 25:1 synchros are driven as the mount is rotated in azimuth and elevation. In the B-50 manual sighting station mode of operation, the GLOW mount is slaved to the output of these synchros and thus is positioned.

1.2 GLOW MOUNT

The GLOW mount is a government surplus Nike-Ajax radar antenna pedestal. With a modification program and a new servo system, a mount was developed having a static accuracy of 0.1 milliradian and a dynamic accuracy of 0.15 milliradian maximum lag error at constant velocities of 40 degrees/second in azimuth and 20 degrees/second in elevation. Peak error of the GLOW mount is 0.6 milliradian at azimuth accelerations of 20 degrees/second^2 and elevation accelerations of 10 degrees/second^2. The GLOW mount servo system is a sophisticated type II servo. It represents a marriage of the latest solid state input amplifiers, compensation networks, and integrators with the hard tube, magnetic amplifier velocity servo loop of the Nike-Ajax radar antenna pedestal. The result is a precision tracking platform that offers maximum adaptability to various types of input error devices. Figure 1-3 is a view of the modified Nike-Ajax radar antenna pedestal. Table 1-1 is a summary of system specifications for the modified Nike-Ajax radar antenna pedestal and associated system.

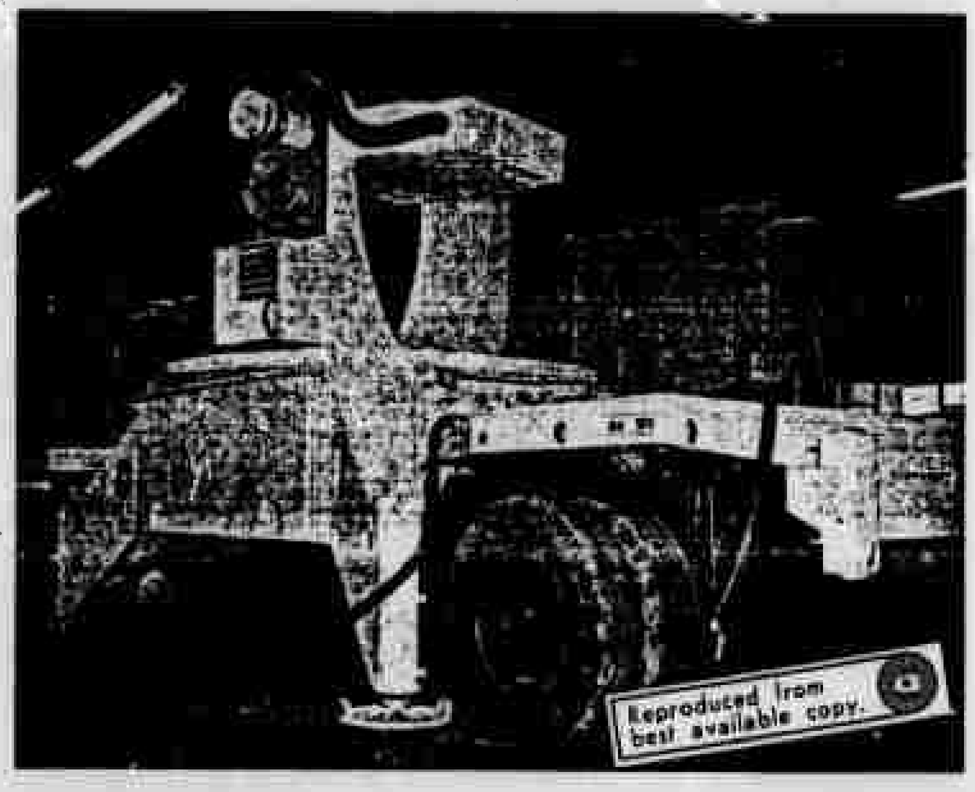


Figure 1-3. Modified Nike-Ajax Radar Antenna Pedestal (GLOW Mount)

Table 1-1 - Summary of System Specifications
Modified Nike-Ajax Radar Antenna Pedestal and System

	Azimuth	Elevation
Maximum Tracking Velocity	750 mrad/sec (43°/sec)	750 mrad/sec (43°/sec)
Maximum Slewing Velocity	840 mrad/sec (48°/sec)	950 mrad/sec (55°/sec)
Maximum Acceleration	800 mrad/sec^2 (45.8°/sec^2)	700 mrad/sec (39.3°/sec^2)
Static Pedestal Accuracy	0.1 mrad RMS	0.1 mrad RMS
Tracking Lag Error (at a constant rate of 40 deg/sec)	0.15 mrad	0.15 mrad
Peak Error (for acceleration of 10 deg/sec^2)	0.4 mrad	0.8 mrad
Open Loop Frequency Response (at unity gain)	4 cps	3.5 cps

Azimuth and elevation readout accuracy 17 bit encoders - 0.05 mrad

Instrument load capacity - 1200 lbs.

The basic modification in conversion of the Nike-Ajax radar antenna pedestal to an electro-optical instrumentation mount consisted of the removal of all non-essential components, fabrication and installation of new motors, re-cabling, and mount refurbishment. The non-essential components removed were the RF lens, RF pod, slip-ring assembly, and a number of RF electrical chassis such as the modulators, transmitters, and HV power supplies. An instrumentation platform, 55-3/4" x 42-1/2" x 10-1/2", fabricated of aluminum, was built up around the Nike-Ajax radar lens support ring. The platform can support 1200 pounds of instrumentation with negligible diaphragming or torsional bending. Instruments are mounted by bolting directly onto the platform faces, which can be drilled and tapped to suit.

Electrical limit stops enclosed in a special module are mounted in the 25-speed synchro pick-off hole. This module is designed to reverse the servo drive motors when a preset limit is reached. Presetting is achieved by adjustable split cams and microswitches. The module design also allows retention of the 25-speed synchro (for slaving purposes) and adds a second synchro which is used to activate a turn counter indicator. Mechanical limit stops are provided to limit rotation to ±2700 in azimuth. These stops consist of a spring buffer mounted on the yoke and two elbow stops located on the pedestal base. An electrical limit switch in the buffer cuts off mount power when the mechanical limits are actuated during mount operation, and when the electrical limits fail to function. Electrical and mechanical limit stops are provided to limit elevation. The electrical limits reverse the servo drive motors when they are actuated (either at -10° or 90°). An override switch permits the platform to be dumped, i.e., rotated through 180° elevation. The mechanical limit stops are at -10° and 190° and consist of a stop pin located on the elevation drive gear which strikes a spring buffer. These stops were reoriented during mount modification.

Azimuth and elevation mount positions are read out by means of a digital data system consisting of 17-bit shaft encoders and parallel-to-series converters (shift register). Figure 1-4 shows the azimuth encoder installation and figure 1-5 shows the elevation encoder installation.

A hydraulically operated crane is bolted on the aft platform of the Nike-Ajax trailer for handling the protective cover and heavy, bulky instruments being installed on the instrumentation platform. It can be rotated about its azimuth axis and locked in position to facilitate lifting instruments and spotting them over the platform. If desired, the crane can be removed and stored horizontally on the platform. Tie points on the trailer are used to secure the crane when not in use. (See figure 1-6.)

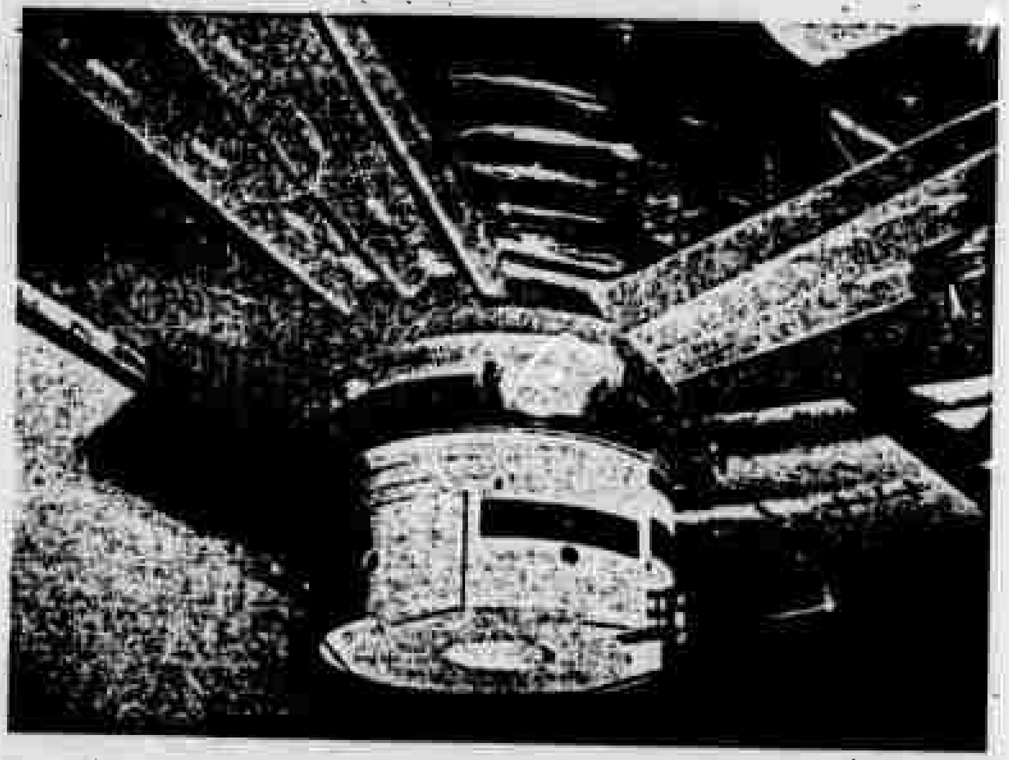


Figure 1-4. Azimuth Encoder Installation and Twist-Up Cable Assembly

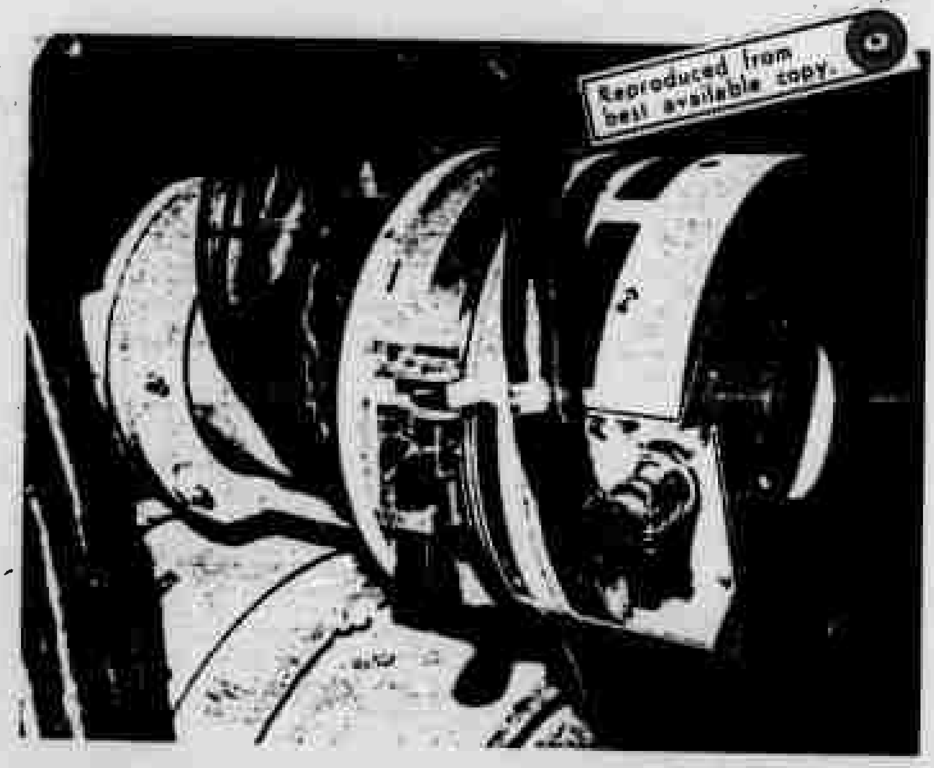


Figure 1-5. Elevation Encoder Installation and Cable Loop

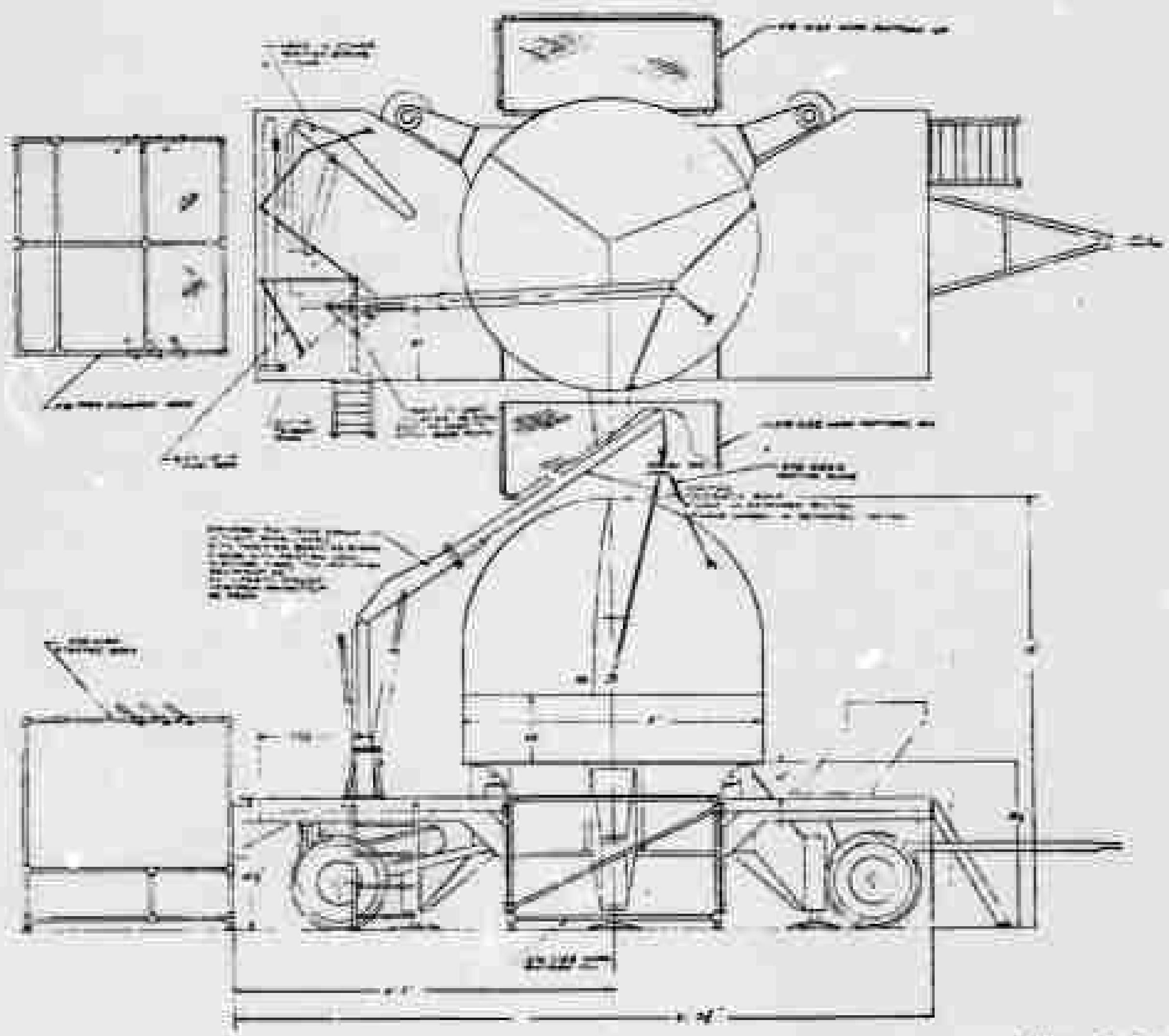


Figure 1-6. GLOW Mount Assembly

At the time of installation the instrumentation configuration was as shown in figure 1-7. Two Perkin-Elmer dual-channel radiometers, with their cryogenics supply, are on top of the platform, while the bottom of the platform contains a 35mm boresight camera on the left and a vidicon television camera on the right. The unit between the cameras is a bracket with lead weights used to balance the pedestal.

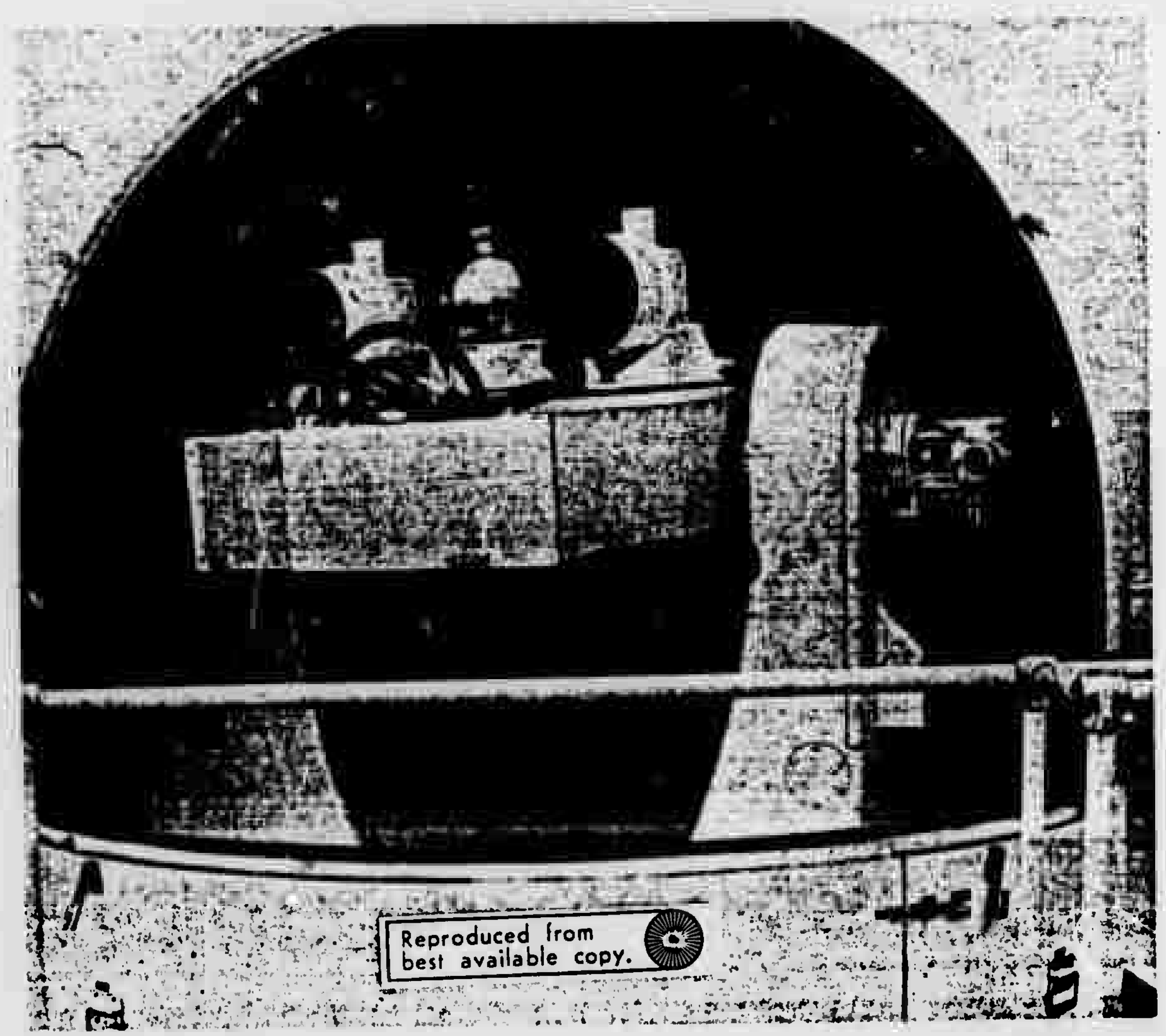


Figure 1-7. GLOW Mount with Instrumentation

1.2.1 Dual-Channel Radiometers

The dual-channel radiometer system serves as a primary reentry measurement instrument complex compatible with the Project GLOW Nike-Ajax tracking pedestal and digital data processing systems.

Design techniques were chosen to favor nighttime reentry measurements under tight tracking control, following early radar acquisition. Particular attention was directed to automatic control and monitoring of performance in real time, in measurement of rapidly fluctuated emissions spanning a wide dynamic range of radiant intensity. Modular flexibility in these instruments allows field substitution of alternate detector filters and field stops meeting the needs of other experiments.

Each dual channel radiometer system, shown pictorially in figure 1-8, incorporates:

1. Two 8 inch aperture dual-channel radiometer optical heads each with its independent Kinematic alignment base and main mounting plate structure.

2. One pedestal-mounted junction box serving as a cable interface, and buffer amplifiers required to raise sensitive signals to levels suitable for transmission through 100 foot cables to the instrumentation van.

3. One 5-liter capacity dual-feed liquid nitrogen dewar and feed system. This assemblage mounts in juxtaposition to the dual-channel radiometer optical heads and incorporates a bracket arrangement for damped pendulous suspension of the dewar.

4. Independent control electronic units, one for each of the four detector channels, rack-installed in the instrumentation van. Each dual-channel radiometer electronic subsystem incorporates a dual beam cathode ray oscilloscope and a monitor panel for easy access and observation of key signal points within the system. Control electronic unit outputs are transmitted to the GLOW Digital Data Handling subsystem for further signal conditioning and tape recording.

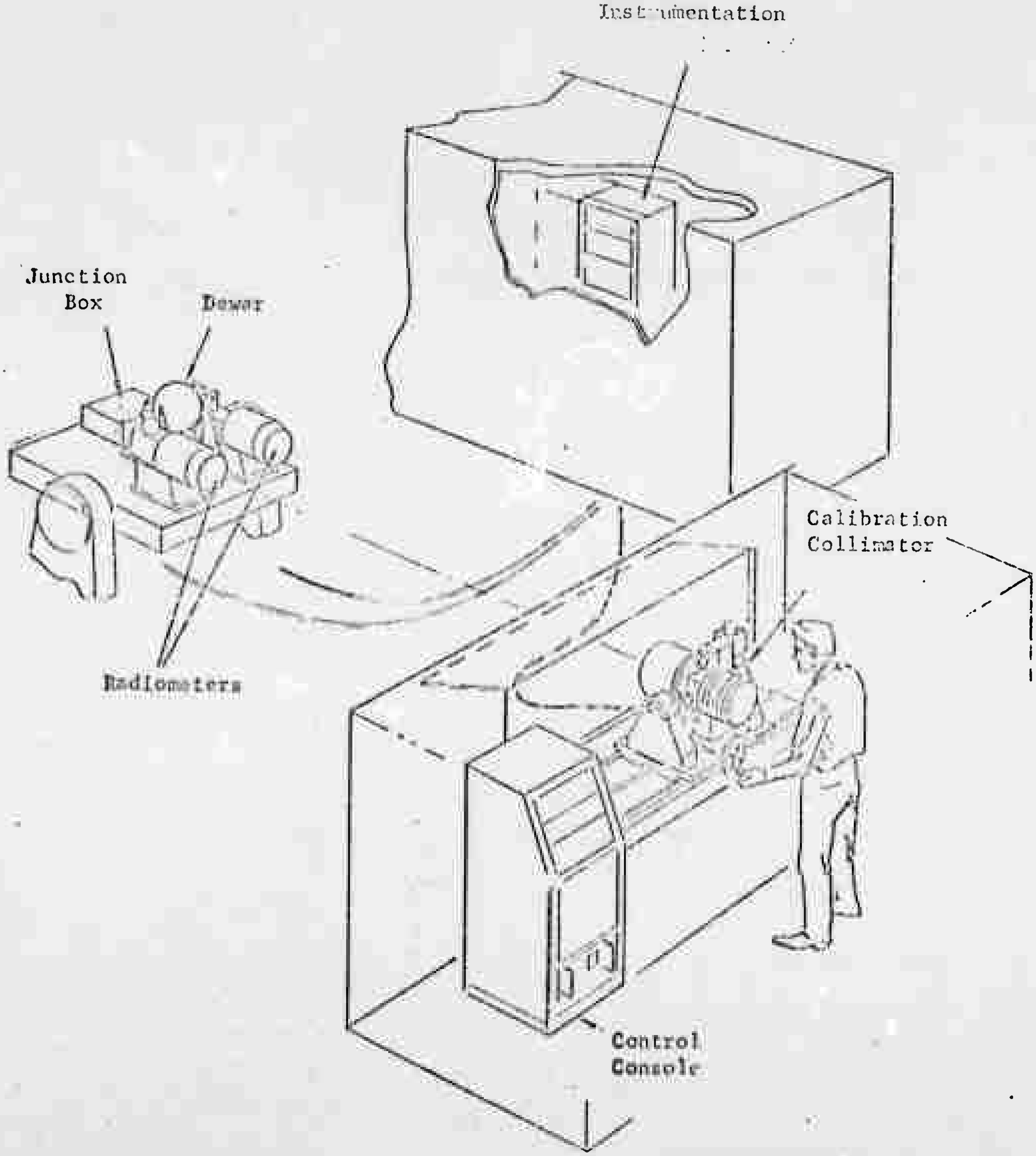


Figure 1-8. Dual-Channel Radiometer System

The dual-channel radiometer, shown in figure 1-9, employs an ambient temperature lead sulphide (PbS) detector for sensing in the spectral region from nominally 5,000Å to 2.7 microns, and a liquid nitrogen cooled Indium Antimonide (InSb) dewar detector for coverage in the wavelength range of 2.8 to 5.5 microns. Independent optical paths to each of these detectors are established by a dichroic beamsplitter, each path incorporating a 4-position remote controlled filter wheel. With the exception of the dielectrically coated filter elements, the radiometer optical path is all-reflected, thereby permitting application of this instrument with suitable change in detectors over a spectral range extending through the visible to beyond 20 microns.

In order to cope with anticipated strong electromagnetic radiation fields, the instrument incorporates a number of radio frequency interference (RFI) immunization techniques, such as RF gasketing, front aperture honeycomb, and RF filter elements.

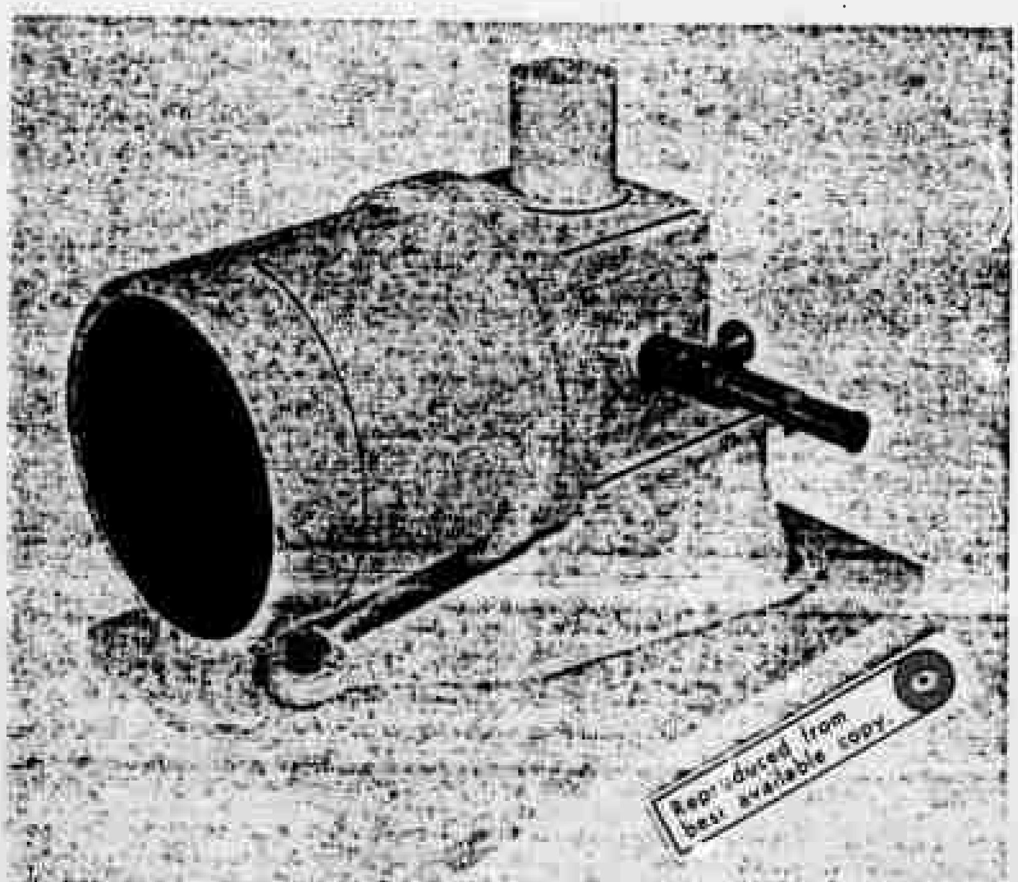


Figure 1-9. Dual Channel Radiometer

The collector system of the dual channel radiometer, a 20 cm aperture, 52 cm focal length Dall-Kirkham design, provides on-axis image quality (90 percent energy) better than 60 microns diameter.

The instrument field of view, 4.0 milliradian diameter, is defined by a suitable aperture stop mounted in the modularized "generator block" assembly. This assembly modulates collected radiation at a 320 cps rate, referencing to an ambient temperature coaxial cavity in alternate half cycles, and includes an independent low speed shutter function (1.90 second exposure, 0.10 second blanking) used for signal control and calibration.

Modulated radiation diverging from the field stop is split by a dichroic filter element in close proximity, with radiation from nominally 0.45 - 2.70 micron reflected to the PbS detector channel, and 2.80 - 8.0 micron energy transmitted in the InSb detector path.

A four-position remote indexable filter wheel in each of the paths permits narrower spectral band definition before collection and focusing of the energy on the detector surfaces.

An all-reflective ellipsoid-planar transfer system serves this function, providing a 3.5X demagnified image of the field stop at the detector plane. This high power transfer system permits use of substitutable pre-aligned detector assemblies, 0.80mm active area diameter, with significant enhancement of instrument sensitivity.

This instrument is furnished with an integrated Kinematic (ball and flat) alignment base and heavy duty mounting plate, designed for precision setting of line of sight to better than 5 arc seconds over a range of 2.0° about elevation and azimuth axes. A removable focal plane microscope assembly (23X) pre-aligned to the field stop center simplifies the boresighting procedure, and assures precise alignment to remote reference targets.

The liquid nitrogen storage and transfer system (see figure 1-10) is mounted in juxtaposition to the two infrared radiometers on the instrumentation platform. A pendulous suspension assembly mounts the spherical dewar. The pendulous mount is employed to maintain dewar attitude vertical under anticipated tracking platform motions and orientation.

Transfer of the nitrogen through independent flexible polyvinyl lines in droplet form (Leidenfrost transfer) supplies coolant to the Indium Antimonide detectors in each instrument. Liquid flow is controlled by solenoids located in each return line in the dewar. Fixed orifices establish optimum flow rate.

The electronics for the dual channel radiometer consists of two independent detector preamplifier modules integral with the radiometer optical head, a single master junction box containing booster and cable driving amplifiers, functionally independent processing control, and monitoring electronics contained in the instrumentation van.

A common monitor panel and oscilloscope facilitate monitoring selected significant signal points within the system.

The electronics operates as follows (see figure 1-11).

1.2.1.1 Signal Channels

The signal channel converts received energy incident upon the detector to electrical signals suitable for recording. Channel No. 1 is furnished with an uncooled biased lead sulfide (PbS) detector and Channel No. 2 with a liquid nitrogen cooled Indium Antimonide (InSb) dewar detector operating in the photovoltaic mode. Except for a low noise input stage in the Indium Antimonide preamplifier, both signal channels are the same.

In the operational mode, radiation on the detectors is double modulated; a four blade chopper giving rise to the fundamental 320 cps carrier frequency, and a rotary shutter in the optical path blocking the modulated signal for a 115 millisecond period every two seconds. During the open period, target radiation changes appear as an amplitude modulation of the 320 cps carrier.

The detector signal is applied to a 320 cps stagger tuned preamplifier, maximally flat, with 3db points at nominally 270 and 370 cps to yield a maximum 50 cps information bandpass. The preamplifier module provides means for calibration injection in series with the detector and voltage applied gain control operating on the transistor h and β parameters. Maximum preamplifier gains are chosen to elevate detector and amplifier generated noise to a nominal 5.0 millivolt rms level for transmission through the long cable lines. Both detectors are transformer coupled to their respective amplifiers to effect a desirable impedance match. In addition, however, the low primary resistance of the input transformer presents an effective dc short circuit to the InSb detector, negating back bias effects, and maintaining relatively constant response under a varying quiescent radiation level. A very low noise stage following the InSb transformer results in an overall preamplifier noise figure of about 1.0 db at 320 cps.

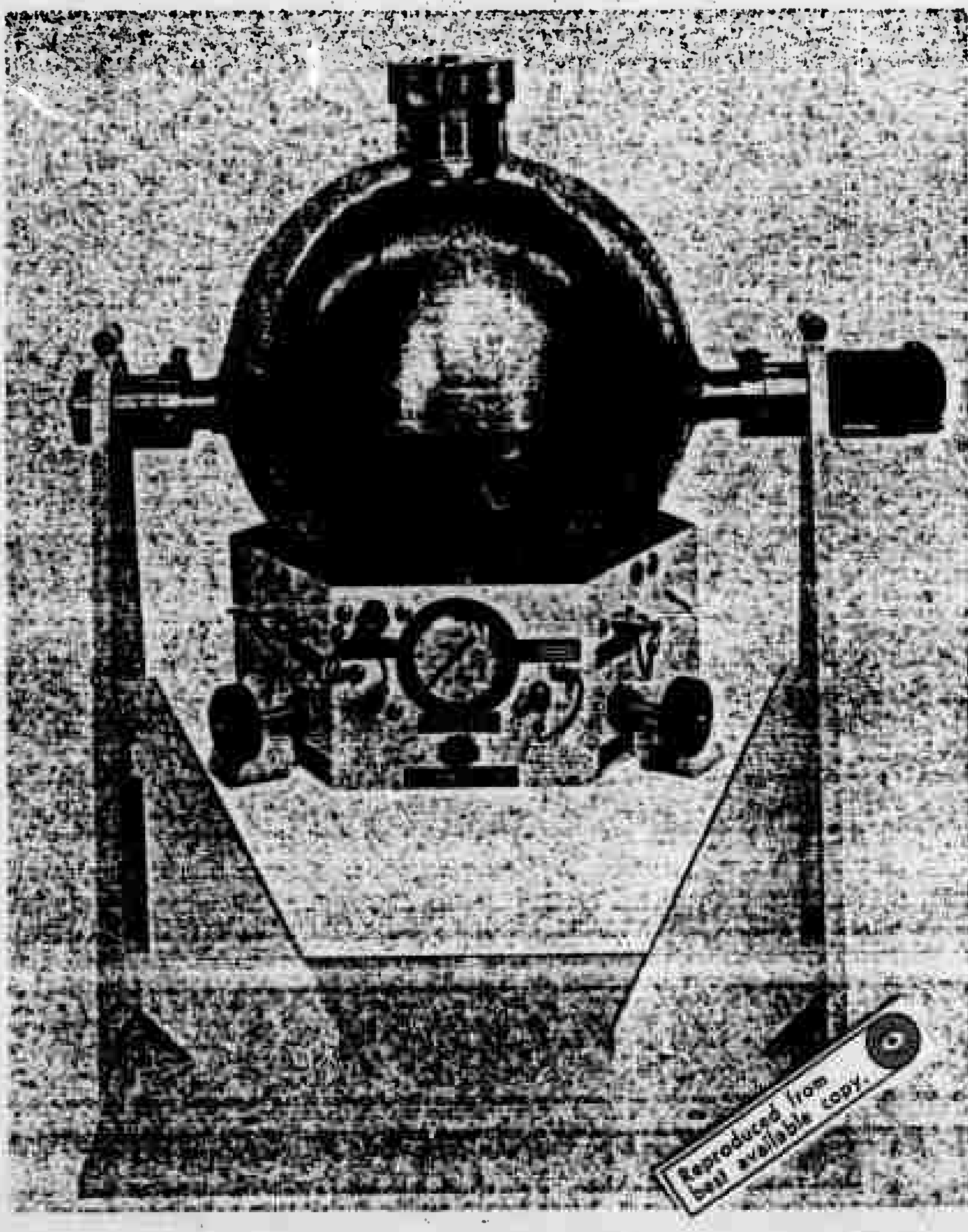


Figure 1-10. Liquid Nitrogen Storage System

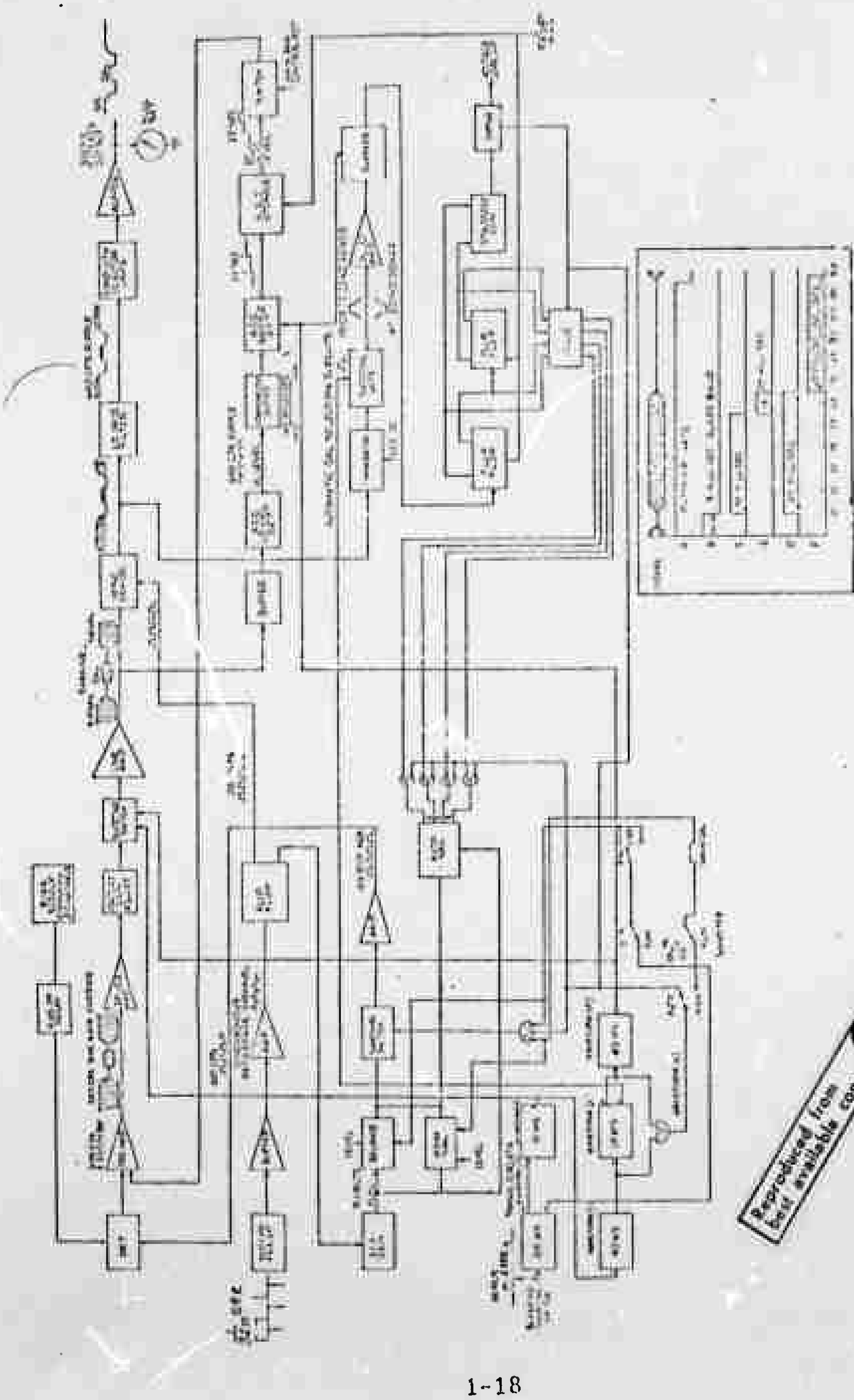


Figure 1-11a

Figure 1-11. Electronics Subsystem - Block Diagram

TABLE 1-2. SUMMARY - INSTRUMENT PARAMETERS

GLOW INSTRUMENTATION MATRIX - PRIMARY INSTRUMENTS									
INSTRUMENT	f/NO.	COLLECTING APERTURE	FOCAL LENGTH	SENSOR	FILTER	FIELD OF VIEW	SPECTRAL REGION	RECORDING MEDIUM	TIMING
DUAL CHANNEL RADIOMETER "A"	2.7	3"	52"	CHANNEL # 1 PBS	1. 0.8-1.3 2. 1.45-1.7 3. 2.0-2.5 4. 0.3-8.0	4mr	0.8 0.8 to 2 7	MAGNETIC TAPE & OSCILLOGRAPH RECORDER	IRIG C
				CHANNEL #2 INSB	1. 3.5-3.8 2. 3.75-4.4 3. 4.5-5.1 4. 0.3-8.0	4mr	1.0 to 5.5		IRIG C
DUAL CHANNEL RADIOMETER "B"	2.7	8"	[illegible]"	CHANNEL # 1 PBS	1. 0.8-1.3 2. 1.45-1.7 3. 2.0-2.5 4. 0.3-8.0	4mr	0.5 to 2.5	MAGNETIC TAPE & OSCILLOGRAPH RECORDER	IRIG C
				CHANNEL #2 INSB	1. 3.5-3.8 2. 3.75-4.4 3. 4.5-5.1 4. 0.3-8.0	4mr	1.0 to 5.5		IRIG C
BORESIGHT CAMERA 35mm FLIGHT RESEARCH	8.0	5"	40"	KODAK FILM 2475	As Required	1 x 1.3°	Visible	35mm FILM	IRIG B
VIDICON TELEVISION	4	5"	20		N/A	2" x 2"	[illegible]	N/A	N/A

NOTE: GLOW System Contains Two Dual Channel Radiometers

Signal outputs from the preamplifiers are connected through 10 foot cables to impedance transforming line amplifiers incorporated in the Junction Box, preparatory to transmission through the 100 foot main cable to the instrumentation van electronics unit. Additional amplification in the van electronics increases signal level to nominally 5.0 volt rms for application to an internal synchronous demodulator and through output cables to signal conditioning circuits associated with the digital tape recording system.

The output of the solid state synchronous demodulator, a bi-polar full wave rectified signal, is applied to a ripple rejecting low pass filter, single time-constant R.C. bandwidth selection filter, and output buffer amplifier. This filtered and buffered signal is monitored by a zero-center front panel meter in each channel (±5.0 Vdc full scale) and made available for detail observation and recording from easy access front terminals on the monitor panel and through the output cable.

1.2.1.2 Synchronous Reference Channel

This channel serves to provide the in-phase synchronous excitation to the demodulator and the calibration reference and balance levels to the preamplifier. Each signal channel has its own independent synchronous reference channel.

The synchronous reference signal is generated by a magnetic pickoff located in proximity to the 80 rps steel chopper blade. The angular position of the pickoff is variable with the system in operation, for rapid coincident phasing between the detector fundamental signal, and the synchronous demodulator excitation. The magnetic sensor output, a train of alternating bi-polar pulses is fed through buffer amplifiers in the junction box to drive the 100 foot cable. Further amplification in the instrumentation van electronics provides drive to a transformer-steering diode trigger circuit for excitation of the 320 cps flip-flop. The resultant square wave is complementary buffered to drive the synchronous demodulator, the calibration and null balance circuits, and made available through the output cable for signal conditioning preparatory to digital tape recording.

1.2.1.3 Calibration and Null Balance Generators

The output of the calibration and null balance generator is a 9.1 volt, 1 percent stabilized 320 cps square wave signal derived from driving a solid state switch alternately between a 9.1 volt temperature stabilized zener diode and ground. This output signal is transformer coupled to a resistor string, providing a precision bi-polar calibration level, and to a continuously variable 10 turn potentiometer to provide bi-polar null balance levels over a 1000 to 1 range.

NULL BALANCE

Channel No. 1 (PbS):	0-1000uv rms sine wave
Channel No. 2 (InSb):	0-10,000uv rms sine wave

CALIBRATION

Channel No. 1 (PbS):	10,100,1000,10,000 v rms sine wave ± 2 percent
Channel No. 2 (InSb):	1,10, 100, 1000 v rms sine wave ± 2 percent

The calibration and null balance levels are switched through logic circuits to a common driver amplifier which feeds the preamplifier calibration input. This amplifier has its input shorted when balance and calibrate functions are not in use.

1.2.1.4 Timing Circuits (See figure 1-11a)

The timing circuits are common to both channels. This network incorporates five monostable multivibrators or "one-shots" functioning to generate the required pulses and gates used as inputs to the comparison and switching circuits. A commutator affixed to the rotary shutter drive closes just before the shutter blocks the energy input to the detector. This pulses the first monostable multivibrator generating the 115 millisecond blanking gate and an inverted blanking gate (balance gate) which removes the null balance level from the signal channels during this period. Initiation of the blanking gate triggers the second monostable multivibrator generating a 15 millisecond pulse used in a shorting switch in the signal channel. The trailing edge of the 15 millisecond pulse triggers the third monostable multivibrator generating a 40 millisecond pulse, which in turn triggers the fourth monostable multivibrator, generating a 10 millisecond pulse. The resultant pulse period sum produces the 50 millisecond calibration gate for injection of calibration level into the preamplifier. In addition, the 10 millisecond pulse is used to sample the calibrate level in the automatic calibration selection circuit. The trailing edge of the 10 millisecond pulse triggers the fifth monostable multivibrator that generates a 60 millisecond AGC gate which closes the AGC sample switch. The AGC pulse like the initial 15 millisecond pulse, closes the signal channel shorting switch thus eliminating spurious signals generated during this period.

1.2.1.5 Operational Modes

The Dual Channel Radiometer operates in either of two modes: Manual Gain Control (MGC) and Automatic Gain Control (AGC). Each channel contains independent circuitry to perform the following:

This Manual Gain Control mode is used primarily for system calibration, test, and set up preparatory to operation in the AGC mode. The gain is controlled manually with the ten turn gain potentiometer on the front panel.

In the Automatic Gain Control mode, which is the system operational mode during a reentry measurement, keyed AGC is employed to keep the rapidly increasing signal within the dynamic range of the system.

The presence of a signal will charge the AGC level detector, which senses peak signal. During the 115 millisecond blanking the AGC gate pulse closes a solid state switch which transfers the detected AGC level to the AGC storage circuit (Sample and Hold function). This fixes a new lower gain in the preamplifier for the subsequent two second measurement interval. As the source increases in intensity, the AGC detector output is further charged and periodically transferred to the storage circuit to reduce the preamplifier gain in steps. The AGC detector is designed with a relative short attach time (two keying sequences) and a very long discharge time, thus mitigating signal drop-out effects due to source obscuration by clouds, etc.

The AGC system is set up to handle a signal increase of ten to one during any two second measurement interval, and will take the system out of saturation arising from an initial input one thousand times greater than threshold in two keying sequences.

1.2.1.6 Automatic Calibrate Selection Circuits

In AGC mode the level of the 50 millisecond calibration carrier burst injected during the blanking period is automatically switched as a function of the changing signal channel gain. Four calibrate levels encompassing a range of 1000:1 in decade steps are available.

The automatically injected calibrate levels are the same as those indicated on the manual CAL LEVEL switch for respective channels. Depressing the AGC RESET button establishes maximum signal channel gain and sets up the minimum calibrate level. The output level during the calibration injection period is sampled every two seconds and applied to a comparator circuit: When the gain decreases to produce a calibrate output less than the comparator reference level (50 mv), a pulse is generated which triggers a counter, switching in the next higher calibrate level. This will appear in

the signal chain in the subsequent calibration period. The counter has a four level capability, switching the calibrate at each step, and retaining the maximum calibrate level until the AGC reset is depressed setting the selection circuits to their initial state.

1.2.1.7 Monitor Panel (See figure 1-12)

The monitor panel is used to facilitate monitoring salient signal points within the dual channel radiometer and is the primary means of establishing system parameters and checking operation prior to a shoot. It is cabled directly to the control chassis, and inspection points are selectable using the selector switches on the panel; thus oscilloscope leads need not be connected into the electronics console. Points which can be monitored are: AC signal (SIG) out. Rectified (RECT) and filtered signal out, 320 cps sync, calibration (CAL) state and ground (GND). The above test points are available from both channels and can be switched to the dual channel oscilloscope as desired. Two jacks for oscilloscope inputs are provided (CH-A, CH-B), allowing two signals from either channel or one signal from each channel to be monitored simultaneously.

1.2.1.8 Signals for Recording

The following signals are provided at the control electronics output connector for transmission to the digital tape recording subsystem:

1. A.C. Signal - Channels No. 1 and No. 2 - 320 cps A.M. - 4.0 v rms max.

2. Synchronous reference (Channels No. 1 and No. 2) 320 cps square wave, 20 v p.p. nom.

3. Null balance signal (Channels No. 1 and No. 2) 320 cps square wave 0 to 10 v p.p. max.

4. Cal Gate and Level (Channels No. 1 and No. 2) 50 millisecond pulse during automatic calibration. Four voltage steps +1, 2, 3, and 4 volts corresponding to 0, 20, 40, and 60 db injected calibrate.

5. Filter Position (Channels No. 1 and No. 2) four voltage levels +1, 2, 3, and 4 volts corresponding to filter position.

6. Internal reference cavity temperature - DC voltage related to temperature (0 - 10 volt max.).

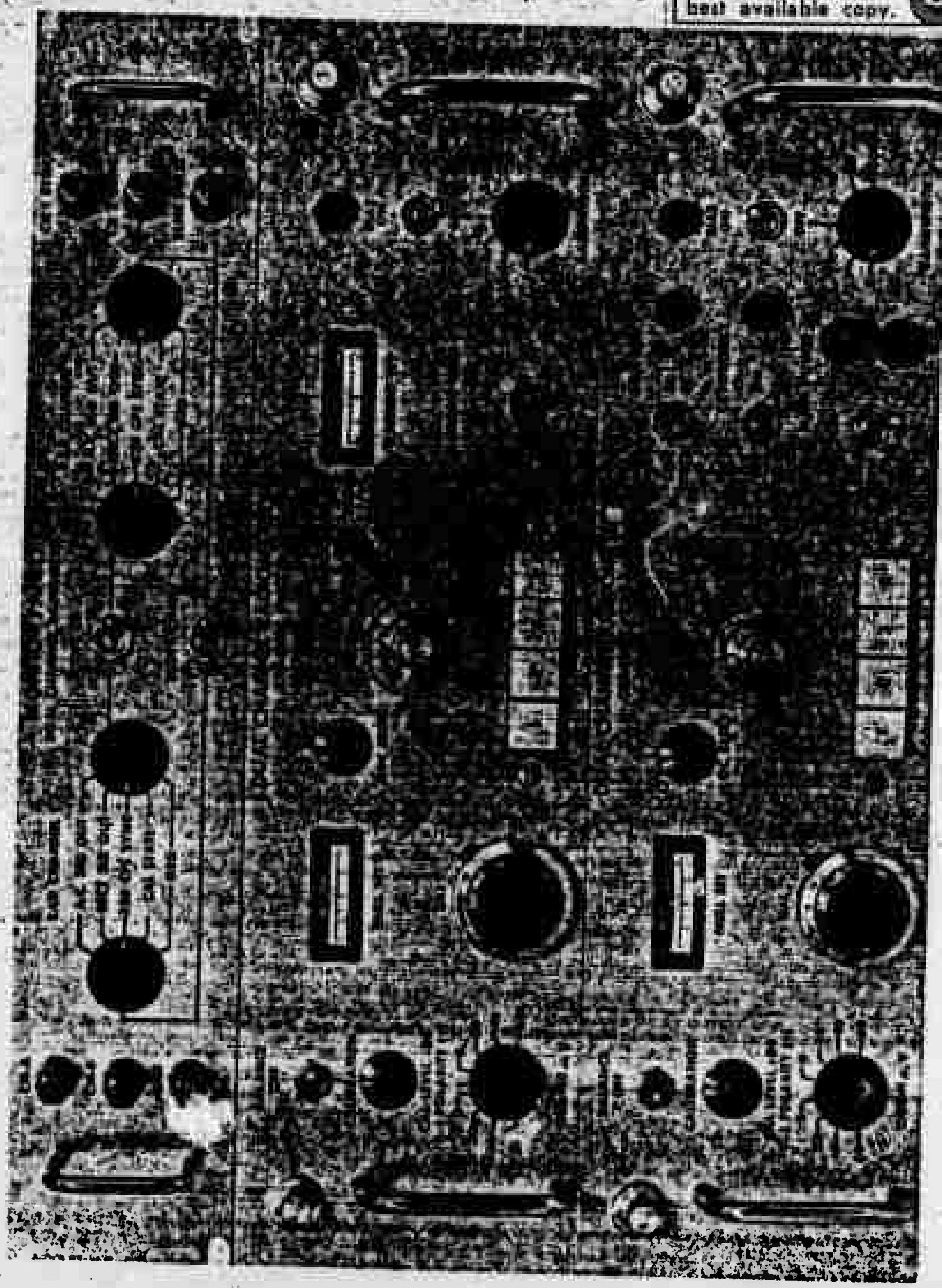


Figure 1-12. Control and Monitor Panels

1.2.2 Vidicon TV System

The vidicon TV system is used to point the pedestal toward the target. Its output is displayed on a monitor on the operators' console in the instrumentation van. It permits the operator to see the events as they take place and to discriminate between the reentry vehicle and other parts of the missile reentering at the same time. Figure 1-13 shows the camera, lens, and mount. The camera also acts as the sensor in the servo loop consisting of the stiff-stick aided tracking system and the operator. The TV system used on GLOW was a high resolution vidicon Cohu Model 3000 camera with a 20-inch focal length optical system in front. The boresight of the vidicon camera is indicated by an adjustable reticle. It was realized at the time of the installation of this unit on White Sands Missile Range that the sensitivity of the vidicon was too low to properly observe a reentry vehicle but it had to be used until the Glint GE image orthicon system became available.

Figure 1-13. Vidicon TV Camera (Viewed from Bottom of Instrumentation Platform)

1.2.3 Boresight Camera

The boresight camera used on the GLOW system is a 35mm photo camera for the time-related recording of line-of-sight (boresight) tracking and instrument performance. Figure 1-14 shows the camera, lens, and mount.

The camera is a Model IV-CLF 35mm Multidata camera made by Flight Research Incorporated. Film format is single frame 35mm (0.720" x 0.960") and ASA Z22.34. The film magazine is externally mounted, dark room loaded, 400 foot capacity and contains a footage counter. Three illuminated fiducial markers are provided for night operation. The field-of-view is 1.0 x 1.3 degrees.

The camera is boresighted and focused by a 3X boresight microscope with cross hairs coincident with the camera fiducial markers. A separate camera mounting base containing micro-adjustments for the camera line-of-sight is used.

The camera lens is fabricated by Zoomar Incorporated, especially for the Flight Research camera. It is a 40 inch reflector lens, f/8, with an internal focusing device, from 600 feet to infinity.

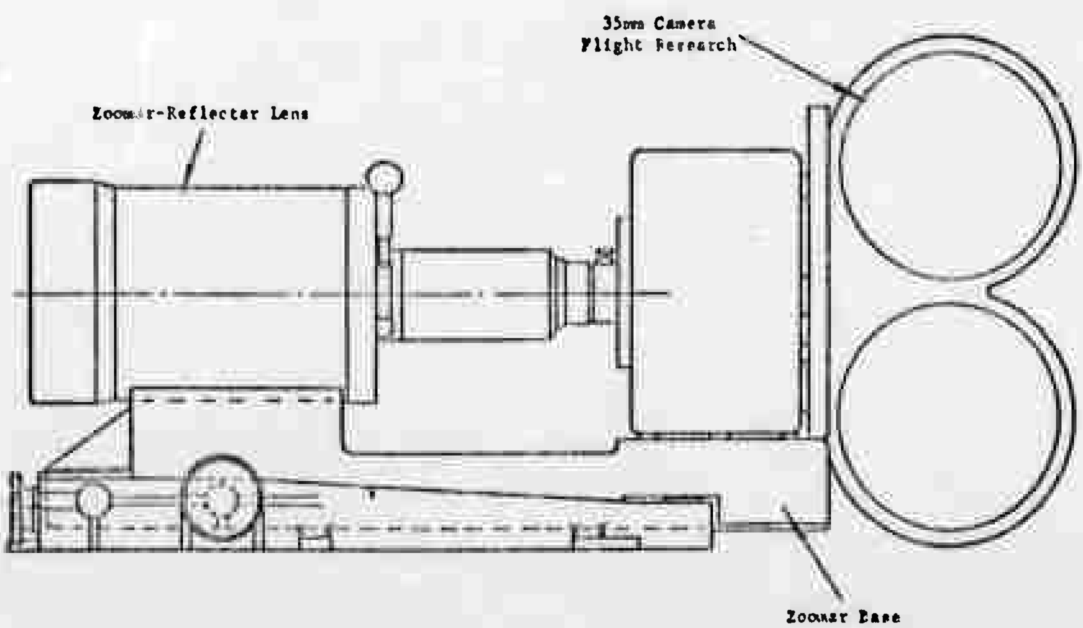


Figure 1-14. 35mm Boresight Camera

1.3 INSTRUMENTATION VAN

The instrumentation van is a 34-foot long semi-trailer van designed to house and transport electronic control and recording equipment for the GLOW program optical instrumentation system. Figure 1-15 shows the instrumentation van.

The instrumentation van is completely enclosed by an aluminum skin over a steel frame and chassis. The aluminum skin was selected for maximum resistance to erosion and oxidation and is insulated against galvanic corrosion.

The instrumentation van designed to meet all Interstate Commerce Commission (ICC) conditions and/or regulations, is permitted to be operated in all states of the Continental United States. The weight of the trailer unloaded is approximately 17,000 pounds. The trailer is designed to transport the mounted GLOW electronic equipment, weighing up to 12,000 pounds, including the air conditioning unit, over highways and unimproved roads.

Figure 1-15. Instrumentation Van

The suspension system is sufficiently self-leveling to accommodate moderate unequal distribution of load within the van and is capable of reducing maximum shocks to be expected under normal rough terrain conditions not exceeding 2.5 G's. A combination air ride and shock absorber suspension is used.

Trailer construction accommodates wiring through a connector panel located in the floor thence to distribution terminals, then to the appropriate equipment racks. Utility power, equipment power, and 400 cps servo power enters through connectors on the side of the van, then through circuit breakers, and remain as separate isolated circuits within the van. A double floor with three inch separation permits cabling distribution to any point in the van. Van construction allows electronic rack mounting through tap plates in the walls, ceiling, and floor of the van for adequate top and base rack fastening devices.

An air conditioning unit is mounted in a separate forward compartment. Figure 1-16 is a view of the forward compartment of the van. Conditioned and recovery air is ducted into and from the instrumentation area of the van.

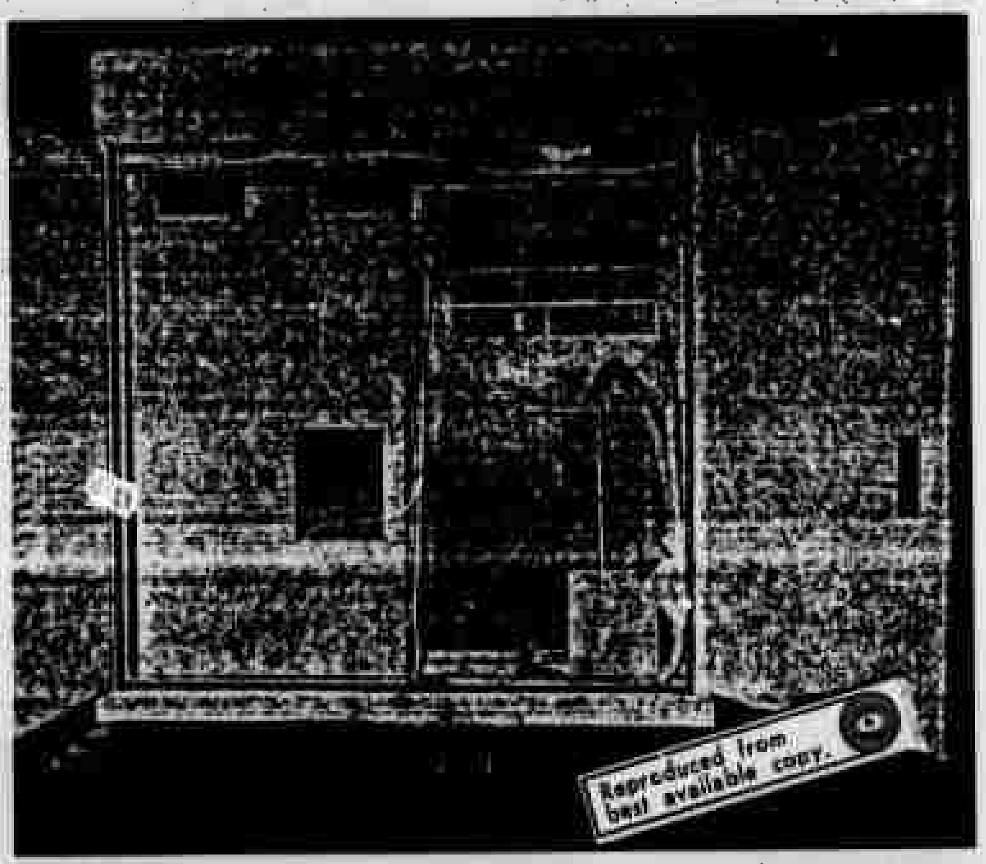


Figure 1-16. Instrumentation Van Air Conditioning Compartment

Adequate filtering of fresh air inlets is provided for protection of equipment in a sand and salt air environment. The conditioned air is distributed through a duct system above the van ceiling, this duct work being equipped with adjustable dampers. The air conditioner consists of a single unit of 60,000 BTU's per hour cooling capacity and 12 KW of heating capability.

An air conditioner remote control panel is located inside the van equipment area. This panel includes the thermostat, humidistat, and selector switch controls.

All doors and access openings are provided with weatherproof gasketing to meet all climatic conditions. Flush type incandescent interior lighting is provided. Interior lighting within the forward control-display console area is separately controllable and includes wall-mounted, continuously-variable, brightness controls, conveniently located with reference to the entrance door. Brightness controls are provided for the instrumentation (rear) compartment interior lighting.

1.3.1 Operator's Console

The operator's console, shown in figure 1-17, is the nerve center for the tracking and pointing system. The tracking operator has visual presentations within his field-of-view for decision making purposes, and he has mode selection switches and a manual control stiff-stick at his fingertips. The console director (left side of console) monitors the autotracker functions, controls the data handling system, and starts and stops film recording instruments.

Visual null indicators, which were developed for this console, present error signals as a line presentation, clearly indicating both magnitude and direction of the error, or of the difference between actual pedestal angles and the pointing angles indicated by any of the other modes of operation.

The console is approximately 76 inches long, 24 inches wide, and 52 inches high with a 20 degree sloping front and a 14-inch wide table top. All panels and electronic chassis are of modular design and are slide mounted to facilitate servicing. The complete console weighs approximately 850 pounds. Appropriate functional displays such as a TV monitor, meters, switches, controls, and indicating lights allow the console director and console operator to monitor and control the instrument mounts and data recording devices. A digital clock on the console indicates time from lift-off. The desired tracking mode of operation is selected by the operator.

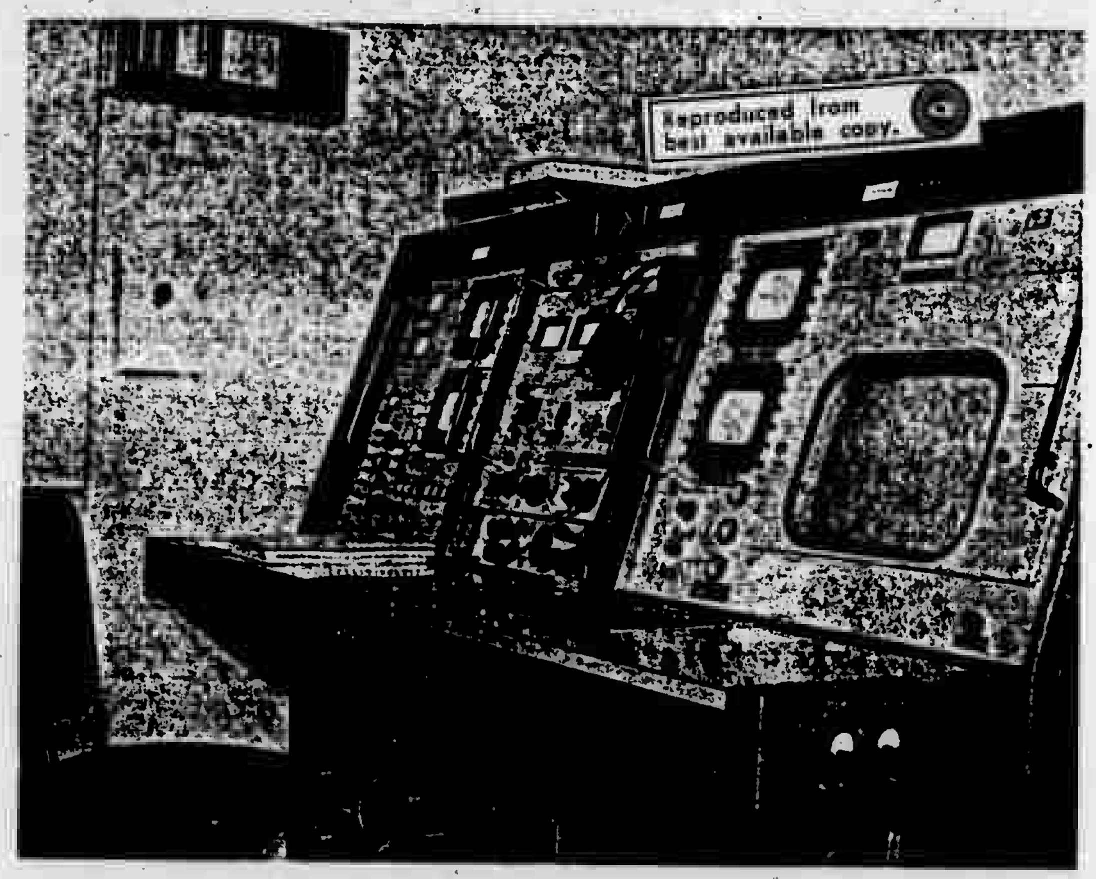


Figure 1-17. Operator's Console

1.3.2 Digital Data Handling System

The Digital Data Handling System consists of two digital magnetic tape units, control and hybrid digital/analog electronics, a Time Code Translator/Generator and a Kineplex data receiver. This equipment is packaged in four equipment racks and a consolette rack. The Digital Data Handling System controls the GLOW mount using command angle information provided by the IBM 7094 computer at WSMR or the GLOW SDS 930 computer at the Kwajalein installation. The system receives and digitizes analog instrumentation data, and records data and tracking information on magnetic tape in a format acceptable to an IBM computer. The system is logically divided into two subsystems as follows:

1. The Data Digitizing and Recording (DDR) Subsystem accepts as many as 64 analog inputs from radiometric and spectrometric instruments mounted on instrumentation platform. The subsystem digitizes and records the data, together with time and tracking data and other required information, on a continuous (gapless) tape. The

subsystem converts the gapless tape to gapped tape in an IBM format during a reformat process.

2. The Tracking Data (TD) Subsystem accepts command angle data from an IBM computer and actual GLOW mount position data from mount shaft angle encoders. The subsystem generates azimuth and elevation servo error signals to control the pedestal position and supplies tracking information to be recorded on magnetic tape.

Figure 1-18 depicts the data handling equipment. Figure 1-19 is a view of the equipment installed in the instrumentation van.

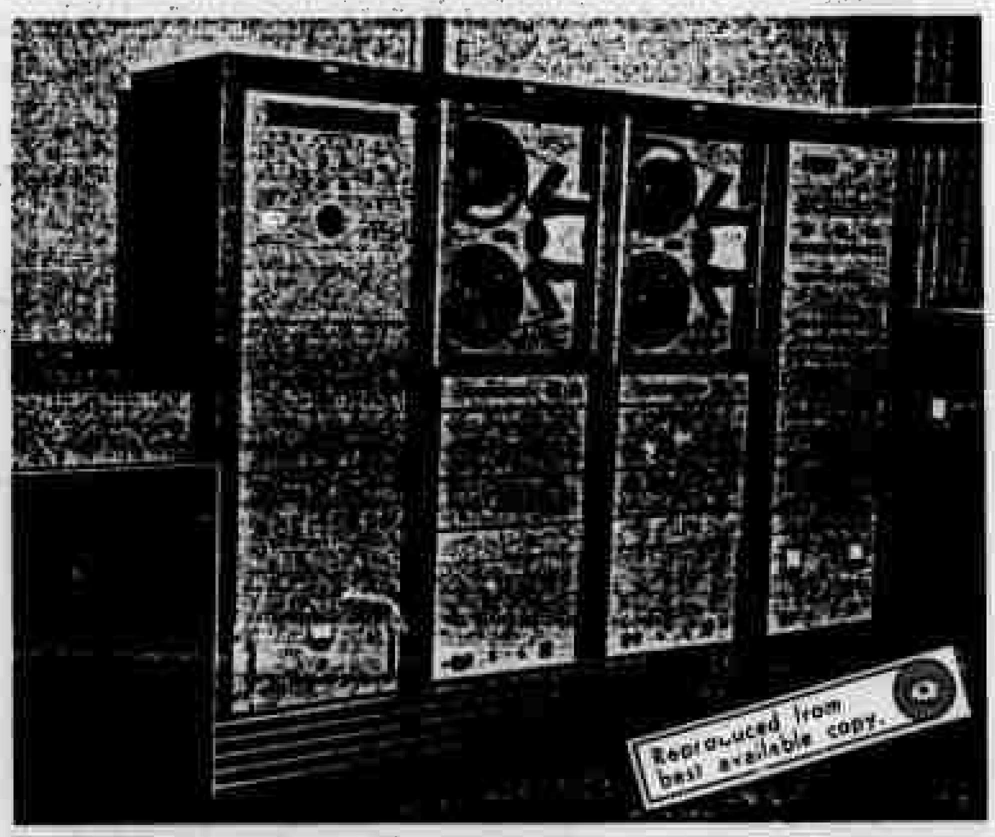


Figure 1-18. Data Handling Equipment

Figure 1-19. Data Handling Equipment Installed in the Instrumentation Van

Sixty-four channels of analog data are accepted as input to the DDR subsystem for multiplexing, digitizing, and recording on magnetic tape. Characteristics of the analog inputs are as follows:

Levels	-	±5 volts peak-to-peak
Loading	-	50 K ohm minimum
Sample Rate	-	200 samples per second

Time-of-day (17 bits) and millisecond time (10 bits) generated by an Astrodata Model 6420-806 Time Code Translator/Generator in IRIG B or C time code format are accepted and recorded by the DDR subsystem. Time code inputs are as follows:

Time of Day 17 lines	-	0 volts for binary one (1) -6 volts for binary zero (0)
Millisecond Code, 10 lines	-	Same as above
100 kc and 20 pps inputs	-	Same as above

A "jam" signal, provided by the DDR subsystem, causes the Time Code Translator/Generator to update the contents of the Time Code Translator/Generator output register just prior to recording time data. Eighteen lines representing discrete events or markers are accepted and recorded by the DDR subsystem. These inputs accept relay closures to ground for a binary zero and an open circuit for a binary one. Two magnetic tape formats are generated by the DDR subsystem. Prime, or gapless, tape is generated during the Operate modes, and secondary, or gapped, tape is generated from prime tape during the Reformat modes. The format of the prime tape is illustrated in figure 1-20. This format is written on both tapes simultaneously during operate modes. Each data block consists of one scan of the 64 digitized analog channels, events data, time data, and tracking data, recorded at a packing density of 556 bits per inch. Three additional tape character positions are reserved in each block for recording an inter-record configuration at appropriate intervals. The inter-record configuration is recorded between groups of 37 blocks. A blank code is recorded between all other blocks. Each group of 37 blocks is considered a record, and the inter-record configuration is detected on playback and used to generate a standard IBM inter-record gap in a tape-to-tape conversion operation. Records recorded on the prime tape terminate with two End-of-Record (EOR) characters, the second EOR character has even parity (a parity error) to uniquely identify the inter-record configuration. Any number of records may be written on the prime tape. When reformated, however, each record is followed by a standard IBM longitudinal parity character and an inter-record gap.

The secondary tape format is similar to the prime tape format, with the following exceptions:

a. An inter-record gap appears between the EOR and BOR characters. This includes the IBM longitudinal parity check character, and conforms to the IBM standard contained in IBM reference manual No. A22-6643 "IBM 729 II, IV, V, VI Magnetic Tape Units, Original Equipment Manufacturers' Information."

b. The second EOR character is recorded with correct (odd) parity.

c. EOF records are automatically recorded only as they occur on the prime tape.

Two types of tracking data are applied to the Tracking Data Subsystem:

a. Command data (azimuth-elevation-range) via the facility computer and,

b. Position data transmitted over the cables from the pedestal-mounted shift registers.

The control and test signals are also transmitted and received from the pedestal equipment.

Position data consisting of 17 bits each of cyclic-binary (Gray) coded azimuth and elevation position angles are generated by Wayne-George Model No. RD-17 shaft angle encoders under tracking data subsystem control. On TD subsystem command, the shaft angle encoders are strobed, and the resulting 34 bits of shaft angle data are transferred to the pedestal-mounted shift registers. Shift pulses shift the data, most significant bit first, into similar shift registers in the Tracking Data Subsystem.

Conversion from cyclibinary code to natural binary code is performed as part of this serial data transfer. Shaft angle encoder operations are checked with verification pulses generated and transmitted from the TD subsystem. Strobe monitor pulses from the shaft angle encoders are used for strobe echo error checks.

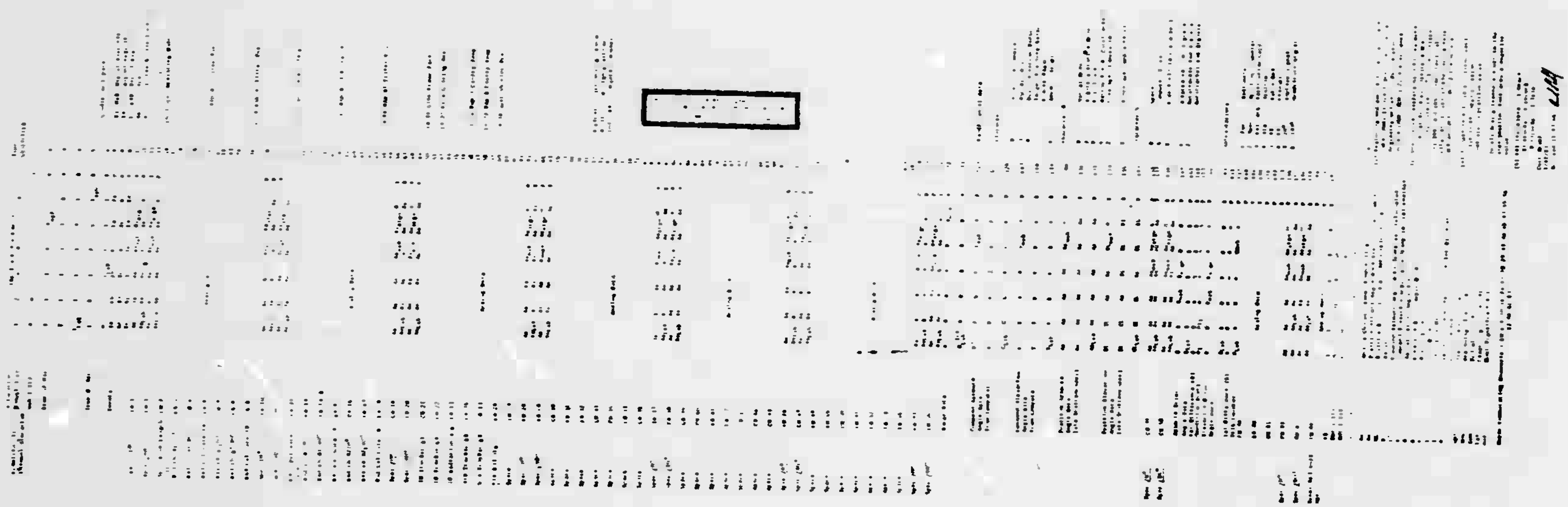


Figure 1-20. GLOW Block Format

The tracking data outputs consist of three analog signals and one digital control line.

1. Range: The range output is an analog signal derived from the 12 bits of the digital range received by way of the GLOW computer, and has a full-scale output of zero to -20 volts, with a constant output impedance of 10 K ohms.

2. Azimuth and Elevation Errors: Azimuth and elevation error signals are generated by digitally subtracting the position angle derived from the pedestal mounted shaft angle encoders from the command angle received.

   Only the 8th through the 16th bits and a sign bit of the resulting differences are stored and converted to analog output form. If the subtraction process results in a difference exceeding the 8th bit, the difference register is set to all ones or all zeros (+ full scale), depending on the sign of the difference.

   The analog output signals are bi-polar, zero to ±6.67 volts (no load), with an output impedance of 6,667 ohms. With 10 K ohm load, the output levels drop to about ±4 volts full scale.

3. Strobe Mode: The strobe mode signal is on (-10 volts) during the time the TD subsystem is operating and strobing the shaft angle encoders. The signal is off (0 volts) at all other times.

The system consists of two digital magnetic tape units, control and hybrid digital electronics, and an Astrodata Time Code Translator/Generator. This equipment is packaged in four equipment racks and a consolette rack. Refer to figure 1-18. (Figure 1-21 shows the screen room for the SDS 930 Computer.)

Rack 1 contains logic cases 1, 2, 3, and 4, the System Control Unit, a PBC Model M2 Multiverter, a PBC Model EM-3 Multiplexer, and a Model MCD2-DA5 Digital-to-Analog converter. The System Control Panel, which provides switches and indicators for local and manual operation of the system, is mounted on the system control unit. Additional system status displays are mounted on the panels of the other units.

Logic case 1 contains the tracking-error-generator portions of the tracking data subsystem, and part of the tracking data buffer. The front panel has 34 indicator lamps, 17 each for command and position angles. A rotary switch on the panel permits selection of either azimuth or elevation data for display.

Logic case 2 contains the GLOW computer and pedestal interface logic and the tracking data subsystem control logic. Two sets of 17 switches are mounted on the front panel for selection of fixed azimuth and elevation command angles during Condition 1 operations.

Logic case 3 contains the digital multiplexer logic and part of the tracking data buffer. The front panel indicators display the state of the digital multiplexer counters.

Logic case 4 contains magnetic tape unit interface logic, tape movement and tape read/write control logic, and an 11-bit analog data buffer register. Front panel indicators display the status of key elements of the tape control logic.

Rack 2 contains a Potter Model 906-II-2 transistorized digital magnetic tape handler capable of reading or writing tapes in IBM compatible format. A power control panel, blower, and isolation transformer are also mounted in the rack. Rack 3 is similar to Rack 2 except the digital magnetic tape unit contains no read electronics. The Astrodata Time Code Translator/Generator is housed in Rack 4.

Two IBM compatible digital magnetic tape transport units are provided with the Digital Data Handling System. Manufactured by the Potter

Instrument Company, the tape units are identical except that one contains both read and write amplifier circuits and one contains write amplifier circuits only. Both units contain:

1. One Model 906-II-2 Transistorized Digital Magnetic Tape Handler with the following specifications:

    a. Tape speed 60 ips, rewind speed 240 ips

    b. Tape width 1/2 inch

    c. IBM type hubs

    d. Isolation transformer (mounted separately at bottom of rack).

2. IBM type End-of-Tape and Beginning-of-Tape sensors including dual channel amplifiers.

3. Model 6400 series IBM compatible single gap magnetic read/write head for operation at 556/200 bits per inch packing density.

4. Model 3321-01R Manual Pushbutton Control Station.

The tape transport in rack 2 has a Model MA315-2 Transistorized Amplifier System for reading and writing IBM compatible 556/200 bpi tapes. The amplifier system consists of the following components:

1. Seven channels of write amplifiers with head compensation.

2. Seven channels of peak detection playback amplifiers with head compensation.

3. IBM compatible clock generator module giving 7 channels of strobed output.

4. All required power supplies, interconnecting cables, and extension frames.

The tape transport in rack 3 is identical to that in rack 2 except the read amplifier circuit cards and the read head cable are not supplied.

The Government furnished equipment items described in the following paragraphs are part of the Digital Data Handling System.

An Astrodata Model 6420-806 Time Code Translator/Generator in its own equipment rack (rack 4) is provided with each Digital Data Handling System. The unit provides the following outputs to the Digital Data Handling System:

1. Time-of-Day, 17 lines: 0 volts for binary one (1) - 6 volts for binary zero (0).

2. Millisecond Code, 10 lines: 0 volts for binary one (1) - 6 volts for binary zero (0).

A "jam" signal input to the Time Code Translator/Generator is supplied by the Digital Data Handling System at least 200μ sec. before data from the Time Code Translator/Generator is to be used, to allow the Time Code Translator/Generator to update data in the output register.

Primary power is supplied separately to each of the equipment racks. Primary power for the Digital Data Handling System is 115 volts, 60 cycle, single phase, three-wire. A service outlet is provided in each rack. The power requirements for each rack, exclusive of service power, are tabulated below:

Rack 1	-	5 amps
Rack 2	-	8 amps
Rack 3	-	8 amps

Power in each rack is controlled by dual Heinemann circuit breakers located on the Power Control panels.

The Digital Data Handling System operates in the instrumentation van shielded against interference from electrostatic and electromagnetic fields. The system operates in the following environmental conditions:

1. Temperature - +10° to +45°C
2. Humidity - 10% to 90% relative
3. Altitude - Up to 10,000 feet

1.4 TARGET BOARD

The system instruments may be boresighted prior to a mission by use of a target board located approximately 1000 feet from the GLOW mount. Each instrument has its own boresight scope either permanently affixed to it or an access port is provided on the instrument for insertion of a boresighting tool.

The GLOW mount is provided with a boresighting telescope and bracket mounted on the elevation axis. The target board is shown in figure 1-22. It is an extremely rigid frame made up of "Unistrut" channel material, suitably braced, bolted and secured in concrete piers. Targets and light sources, as required for each individual instrument, are made up in "Universal" type mounting fixtures, affixed to the target board frame, and positioned on the board so as to eliminate parallax errors when boresighted. The target board allows maximum flexibility for interchanging targets or relocating them as new instruments are added to the system. It also makes boresight check possible without regard to cloud cover.

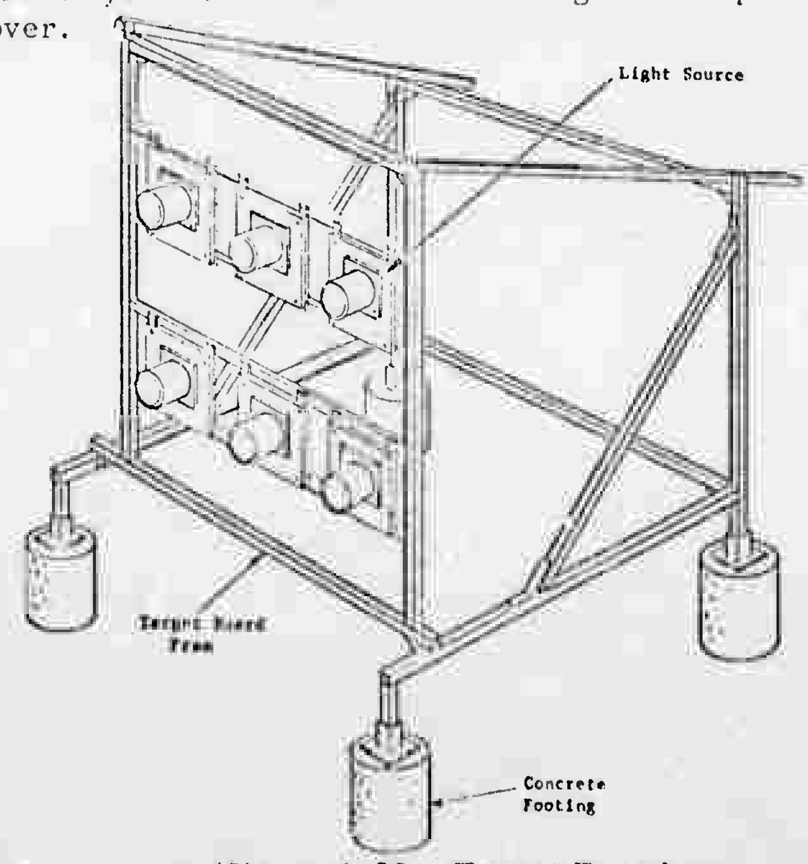


Figure 1-22. Target Board

1.5 CALIBRATION COLLIMATOR

A precision reference collimator system is provided in order to facilitate field calibration of the GLOW instruments (see figure 1-23). The calibration system consists of a large aperture, all-reflective, collimator with a precise, controlled energy source. Appropriate alignment sights and position controls are provided to enable the operator to set up quickly on the various instruments.

The calibration collimator (with source) is mounted on a concrete pier, located within 50 feet of the GLOW mount, with the railbed positioned tangent to a circle concentric to the azimuth axis of the GLOW mount (see figure 1-24). Horizontal translation of the collimator on the railways and vertical angular position about the collimator's horizontal mounting axis provide for alignment of the collimator axis to any one of the instruments on the GLOW mount. The combined use of a direct viewing telescope mounted on top of the collimator, and a reflex viewing system through the collimator optics, enables the operator to guide the positioning of the collimator optic axis to coincide with the axis of a particular instrument on the GLOW mount.

A choice of aperture sizes for the blackbody source field stop, along with a variable temperature control for the blackbody, provides a wide range of energy levels from the collimator. There is a secondary source available, in that the illuminating Osram lamp with mercury spectral bands or peaks can be used as a source. Optical filters are available for insertion into the energy beam, providing spectral region control. A mechanical chopper provides square wave modulation of the source energy, as desired, for instrument dynamic performance evaluation. Provision is made for making precise field-of-view tests on the instruments.

The collector system of the 12-inch calibration collimator utilizes a parabolic primary mirror and a hyperbolic secondary mirror in the standard Cassegrain configuration. The effective focal length (EFL) of the collector system is 15.14 inches, which results in an overall collector speed of f/4.35. Nominal on-axis imagery is 20 microns.

The collector system is housed in an aluminum alloy casting. The primary mirror is supported on 3/8-inch diameter, 50 durometer silicon rubber that extends around the complete periphery of the mirror. This ring allows for differential expansion between the mirror and the housing throughout the expected temperature range and also provides a shock resistant mounting for the mirror. The secondary mirror is also mounted with a rubber, shock-absorbing member.

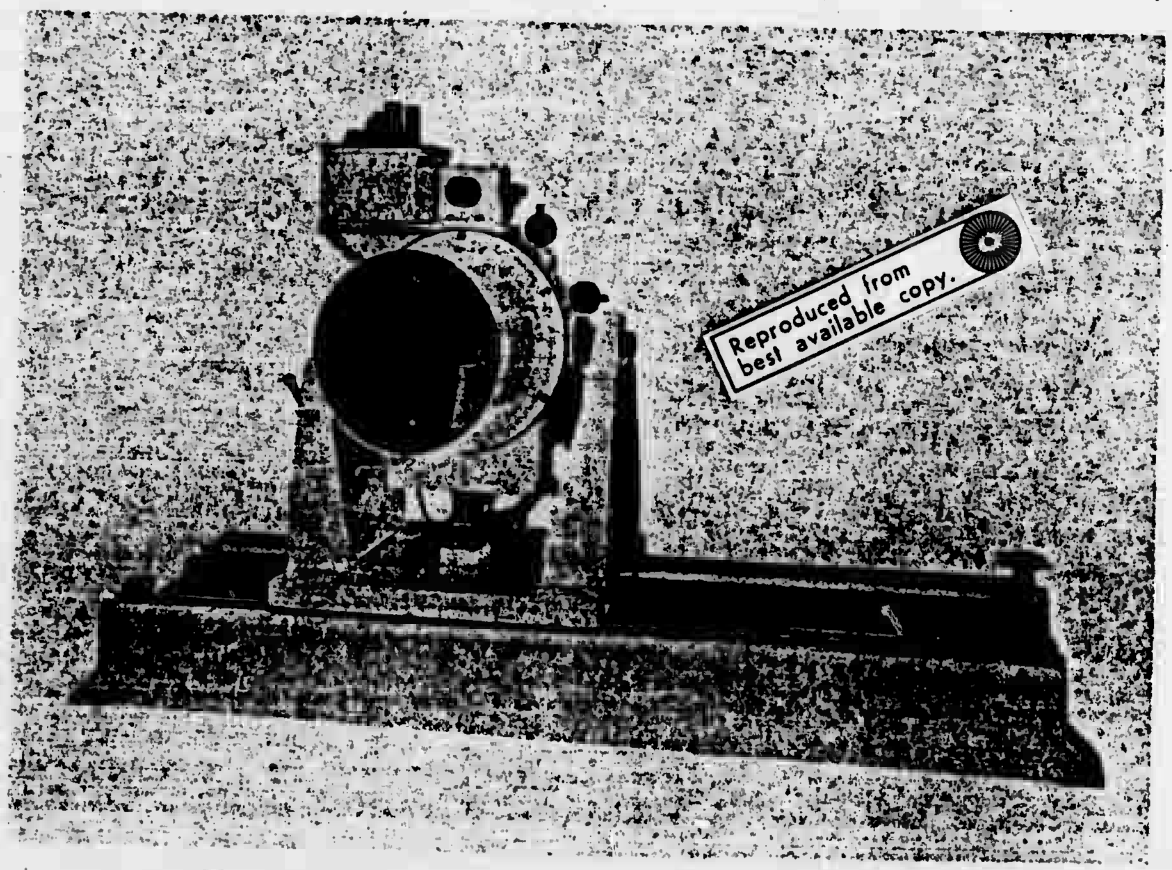


Figure 1-23. Calibration Collimator

The Cassegrain optics perform the dual system functions of collector and projector. Energy at the foeal point of the optical axis is collected and then projected to the instrument to be calibrated. As a projection system the unit projects energy from a blackbody source through a selection of various diameter pin holes and filters. Two index wheels are used to allow combinations of different pinhole apertures and filters. Each wheel contains six index positions; one wheel has six filter holders, the other has six pinholes (field stops) of varying aperture size. Both pinhole and filter selections are made manually by knobs located on the light modulator assembly at the rear of the collimator.

Three possible foeal point positions within the calibrator are provided for the colleetor system. The focal planes that are utilized are determined by the position of the flip mirror.

When the flip mirror is in the down position, the blaekbody field stop is at the focal plane No. 1 of the collector system and a 5X boresight scope is in position for x and y alignment of the collimator with respect to the instrument under test.

When the flip mirror is in up position the calibrator:

1. projects visible collimated light from the Osram source to illuminate the focal plane of the instrument under test,

2. provides a 50X telescope through which the illuminated focal plane of the instrument under test may be viewed.

The dual capability which is realized when the mirror is in the down position is accomplished optically by a beamsplitter in the optical path. By centering the field stop at the focal plane of the test instrument on the crosshair reticle of the calibrator telescope system, the optical axis of the calibrator is rendered parallel to the optical axis of the instrument under test. Thus by using both positions of the flip mirror, it is possible to assure that the optical axis of the collimator and the instrument under test are parallel and coincident with one another.

The light source that is used for the projection system is an Osram type HBO 100 W/2 high pressure mercury lamp. Light from the lamp is transferred to the rear projection screen, located at focal plane No. 3, by a Schneider Zenon lens system. Cooling for both the lamp and the lens is provided by a vane-axial fan and an adjustable baffle to regulate the air flow. The ignition system for the Osram lamp is mounted in the same aluminum casting and both units are accessible through a cover plate.

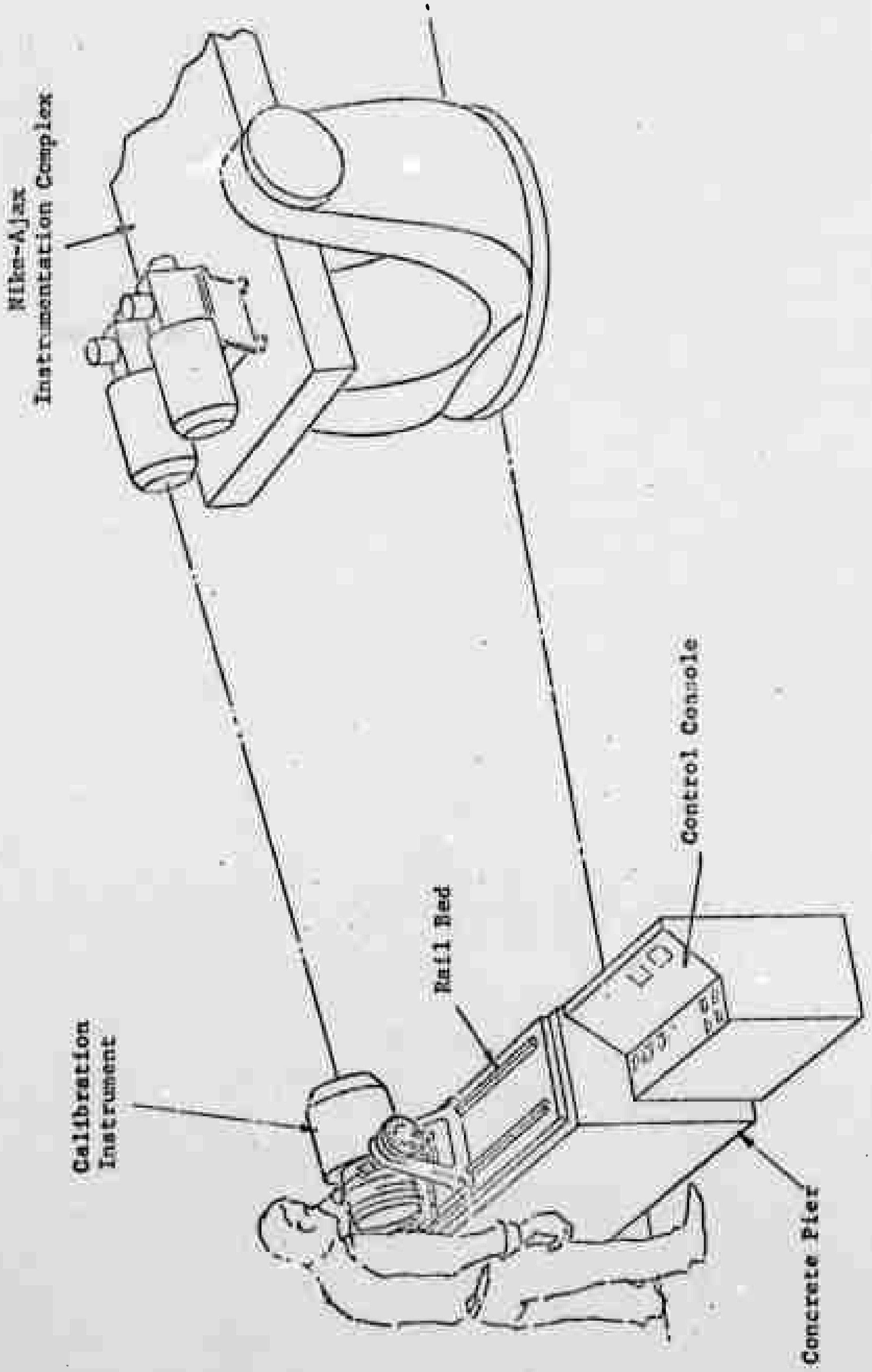


Figure 1-24. Calibration Instrument at GLOW

To provide for alignment of the calibrator with respect to the x and y axes of the instrument under test, the entire unit is mounted upon a trunnion and slide axis to allow positioning of the carriage to within ±1/32 inch. A rack and pinion drive that is manually operated through a hand wheel is provided to move the trunnion along the railbed. Precision ground and polished ways allow the trunnion to slide over a distance of 40 inches while retaining angular position to within 10 arc-seconds. An elevation drive and lock system allows elevation adjustments with a precision of ±15 arc-seconds.

1.5.1 Control Console

The control console shown in figure 1-24 and 1-25 is a sealed electronic cabinet which is a functional part of the calibration collimator system. The control console contains a control panel with on-off switches for main power, the Osram lamp, and the blackbody modulator. It also contains the power supply for the Osram lamp and a radiation source temperature controller.

Packaging and electronic wiring within the control console provides a flexible arrangement for system growth. For this purpose the following has been provided: a radio frequency interference filter at the AC input termination to limit conducted interference, space within console cabinet for future subassemblies, and terminal strips to provide power and control functions for the future subassemblies.

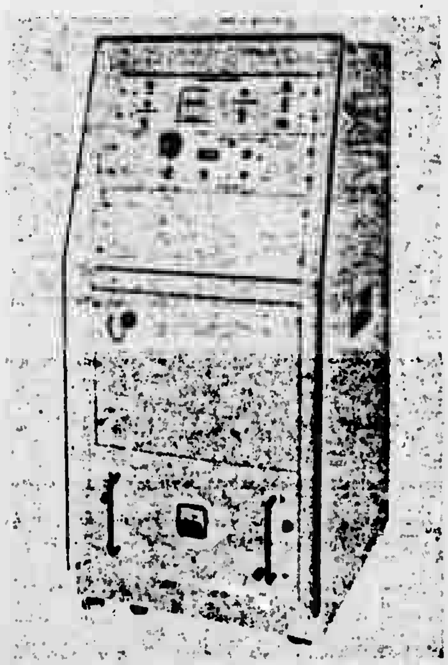


Figure 1-25. Control Console

1.6 UTILITY VAN

The utility van (see figure 1-26) is a 28-foot long semi-trailer van (GFE) which provides storage and maintenance facilities for the GLOW site. The van also contains a darkroom. A view of the van interior is shown in figure 1-27. Storage cabinetry, heater-air conditioner and B-50 manual sighting station support are also shown.*

1.6.1 B-50 Manual Sighting Station

A B-50 manual sighting station (see figure 1-27) was chosen for a visual means of target acquisition, i.e., a manual sighting station for the GLOW system. The GLOW mount is synchro-slaved to the sighting station during periods of time when the sighting station is the mode of acquisition. In order to make the B-50 station compatible with the GLOW system it was modernized and refurbished.

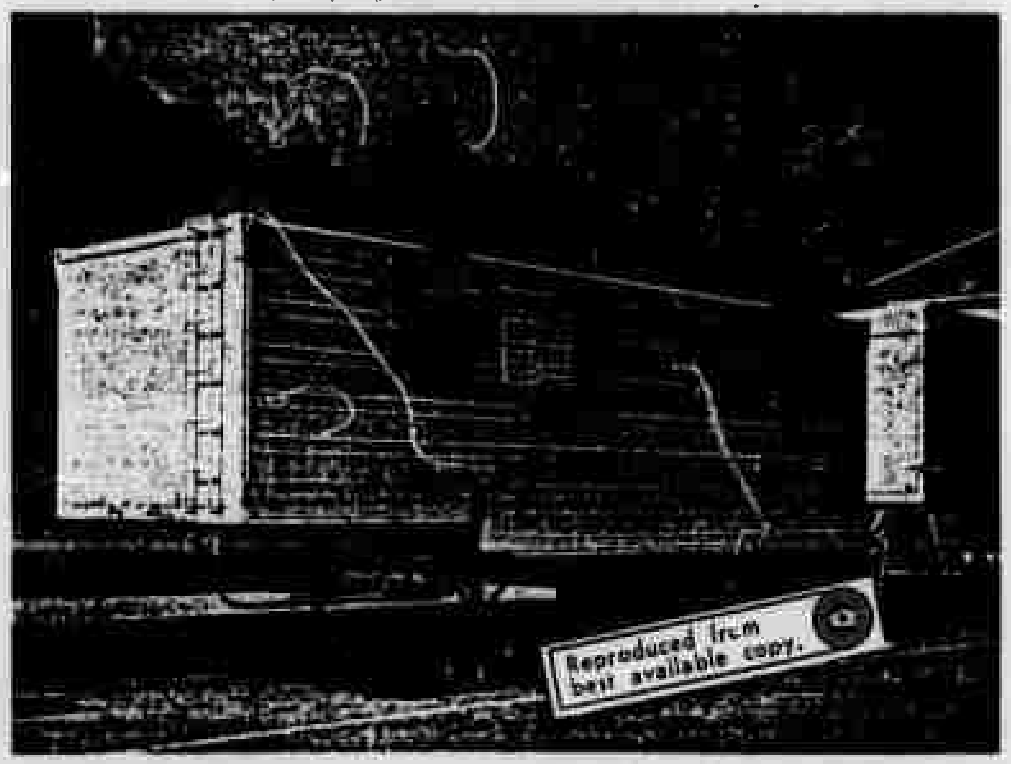


Figure 1-26. Utility Van

*At the Kwajalein installation, the manual sighting station is located in the GLOW facility building

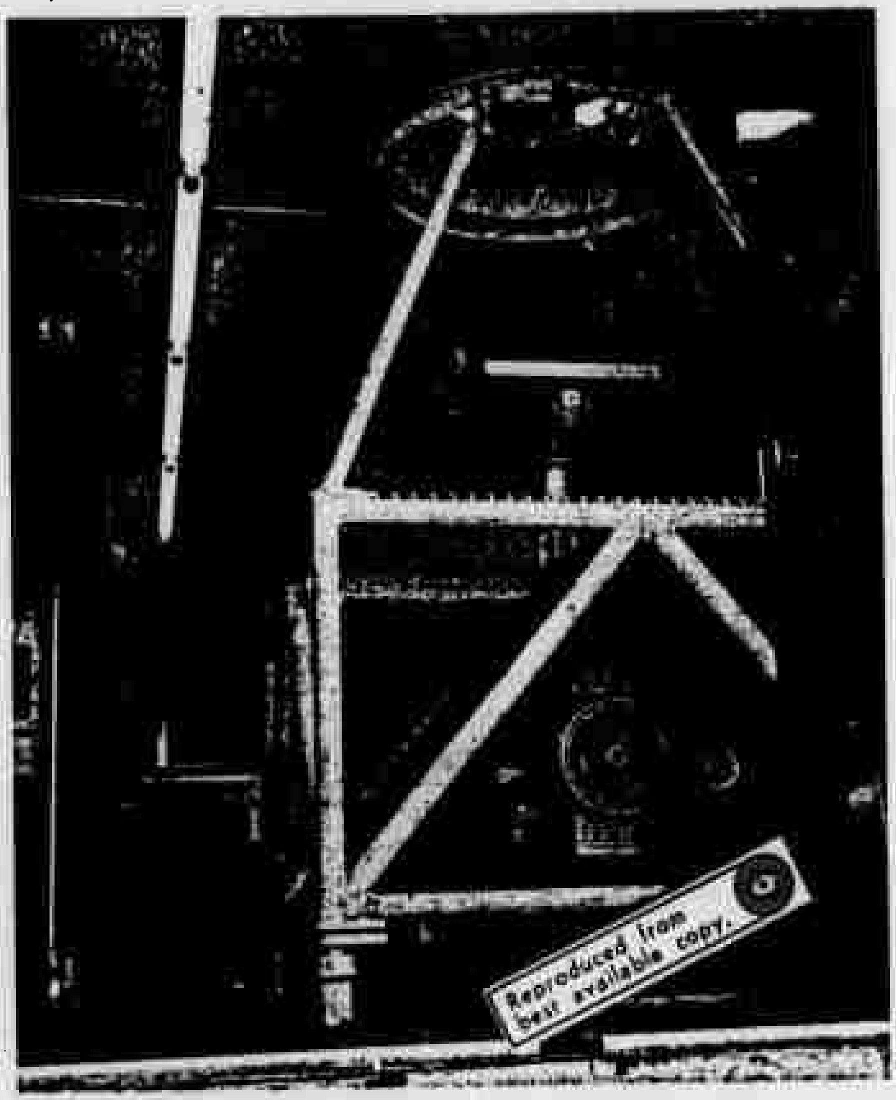


Figure 1-27. B-50 Manual Sighting Station Installation

Non-essential items, such as the gyros and the ranging device were removed. The 31-speed synchros were replaced by 25-speed units. This was accomplished through rework of the gear boxes to make the system compatible with the Nike-Ajax synchro system. A synchronizer, using solid state circuitry, was provided for automatic switching of the 25-speed and one-speed synchro transformer outputs. The reflex sight was reworked to provide an illuminated, variable intensity, collimated reticle display. A precision level was added to aid in leveling the unit, and the elevation axis payload was properly counterbalanced for easy operation. Viscous dampers were added to the azimuth and elevation axes to insure smooth tracking.

1.6.2 Darkroom

The darkroom (see figure 1-28) is located in the forward end of the utility van. Suitable cabinets, work space, ventilation, and water supply are contained within the room to allow development of photos and camera test films.

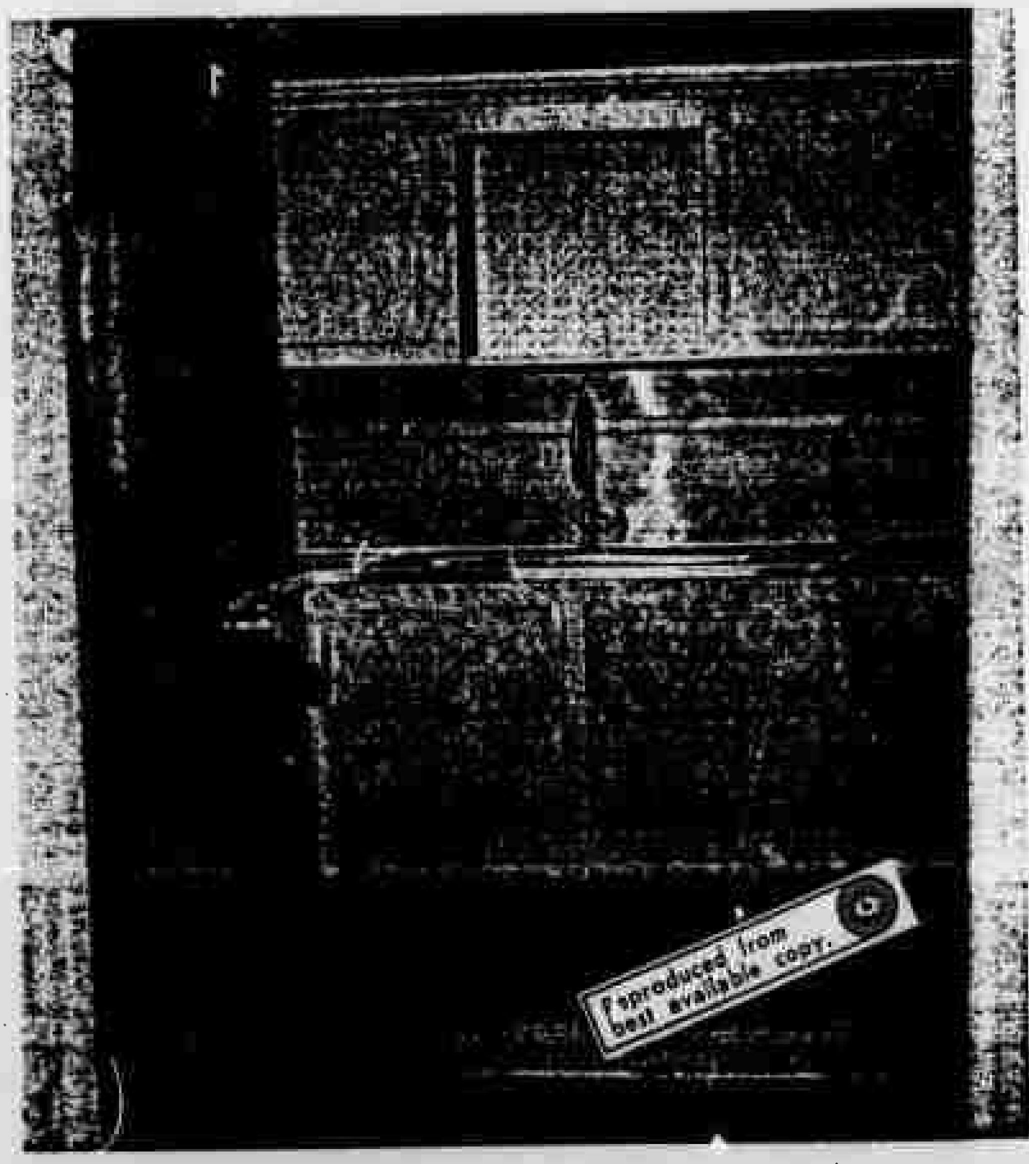


Figure 1-28. Darkroom

1.7 FREQUENCY CONVERTER UNIT

Power is supplied to the GLOW site from the range power lines. These lines are connected to a 30 kilowatt motor-generator set (see figure 1-29) which converts the 60-cycle AC range power to 400-cycle AC power for use in the GLOW site.

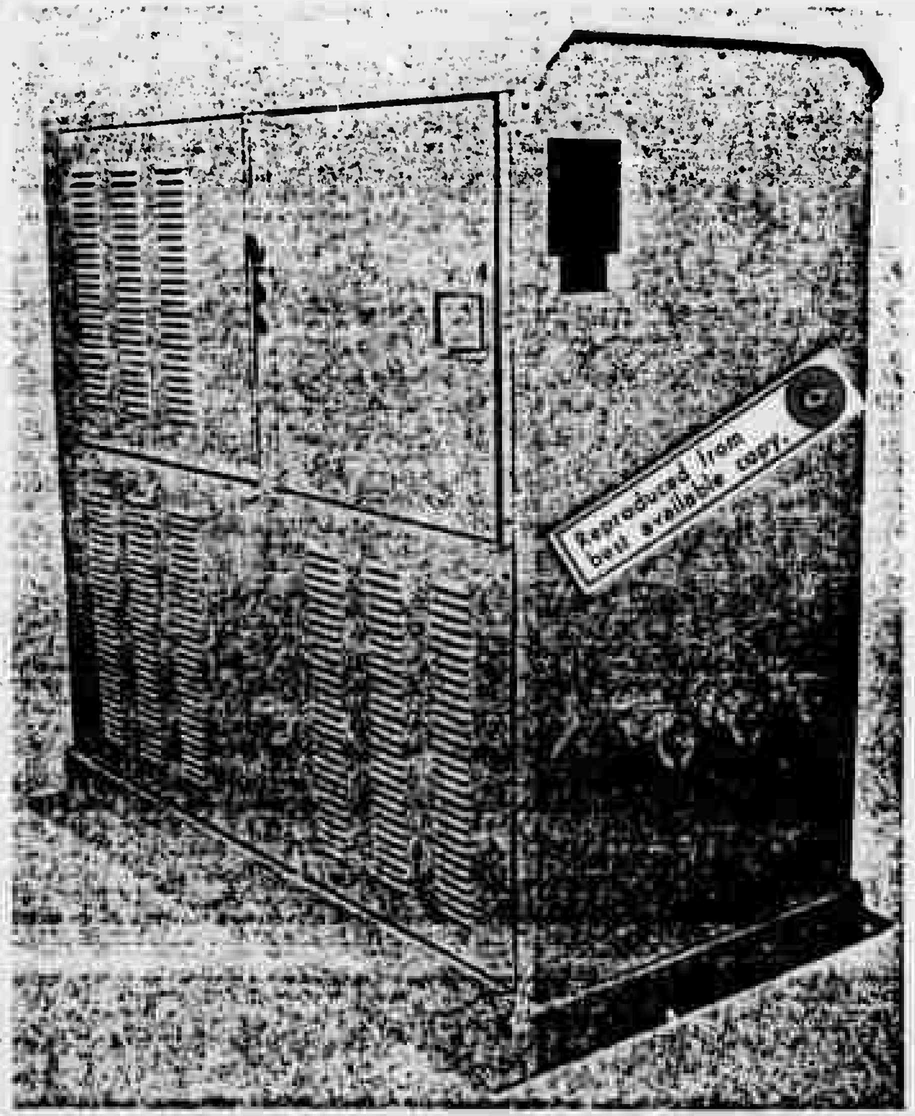


Figure 1-29. Frequency Converter Unit

1.8 COMPUTER FACILITY

The addition of the SDS 930 general purpose computer and its peripheral hardware (teletype writer, magnetic tape recorder, and a high speed paper punch reader and writer) enables the GLOW system to become a self-sustained tracking system.

In addition, the computer may be programmed and utilized to generate any function desired for static or dynamic listing of the system's servo system.

The computer equipment is located in a screen room within the main GLOW facility building.

In order to prevent the generation of erroneous signals, caused by the close proximity to high radiant fields, all equipment and incoming signal lines are adequately shielded and/or filtered.

1.8.1 Basic Operation

The computer complex can be broken down into three distinct interfaces:

1. The general purpose computer
2. The input-output junction box of the computer
3. I/O interface assembly rack which integrates the range facility lines to the GLOW complex.

Figure 1-30 details in block diagram form the computer equipment and interface.

The system in its operational mode can convert the various radar data (TRADEX, TTR, and DR) to a GLOW coordinate at a 40 message per second track rate. (The present site, due to its logistical problems, had only the Tradex pointing data available during the installation.)

The incoming data is assembled in the I/O interface rack where it is serially decoded; after decoding has been accomplished, the computer is interrupted, indicating that the message has been assembled and it is ready to be utilized for computation purposes.

The computer then interrogates and converts this data to the GLOW coordinate site.

The incoming message, therefore, is compensated by translating it (shifting origin), updating it from a 10 message rate to a 40 message per second rate, and adding all the lag parameters associated with the message computation time, transmission delay times, and mount lag.

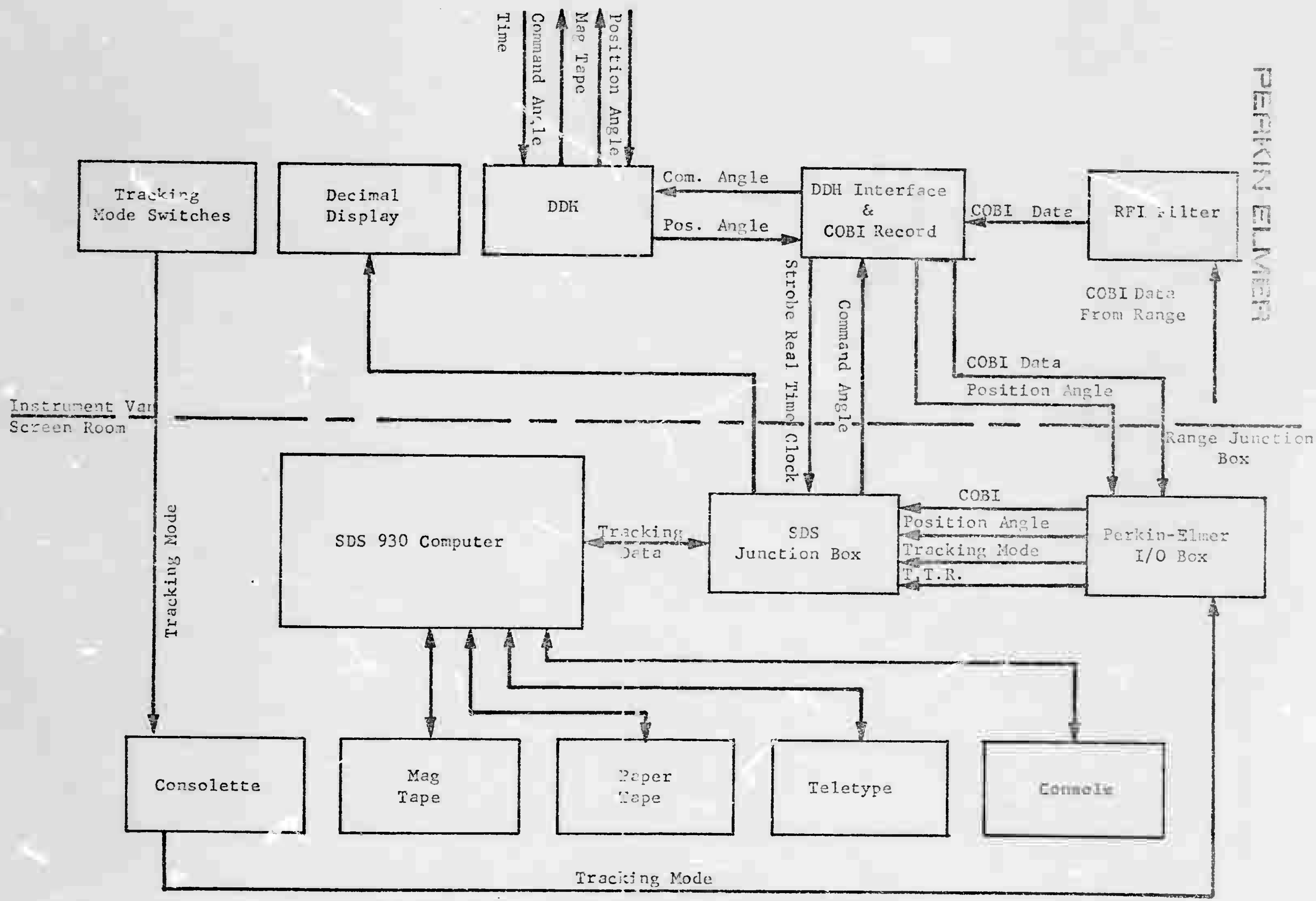


Figure 1-30. Block Diagram of Computer Interface

The updated data is then transferred to the GLOW DDH system where a comparison is made between the pedestal azimuth and elevation angle with respect to the computer's input command position angle. The differences between these two quantities (command and position) are used to generate a servo error to drive the pedestal.

In addition, all of these data points are also converted in the computer to a binary code decimal number and transferred to the van for display purposes.

The display consolette, as pre-programmed, can display the following quantities: range, azimuth and elevation position angle, and azimuth and elevation TRADEX input angle. During tracking, the mission director's capability is enhanced since he is permitted to view the system's tracking accuracy. The display console shows the actual pedestal position and the difference between the command angle and the pedestal position.

The system has been designed to accept other radar information as they become available. This data may be utilized, in conjunction with the existing data, to increase the acquisition and tracking capabilities of GLOW.

1.8.2 Equipment Description - Perkin-Elmer Fabricated and Designed

Equipment designed and fabricated by Perkin-Elmer for this interface is described in the following paragraphs.

A complete operational description is detailed in Engineering Report No. 8622, "Computer Extension to GLOW System", dated 14 December 1966.

1.8.2.1 Operator's Consolette. The consolette is provided for communication and display of system status. It is also utilized as a junction box to terminate tracking mode information from the Instrument Van Operator's Console. The equipment is designed to be emplaced on the computer control console table.

The display is divided into four panel sections. The TRADEX (or COBI) section displays sync and parity errors detected by the TRADEX assembler logic. There is a display to indicate that the TRADEX message is being transmitted and another to indicate that the TRADEX message has been selected for tracking data. A TRADEX test mode switch is provided to gate computer data through the TRADEX assembler logic for test purposes. Note that the test is automatically disabled when the "Computer Ready" switch, located on the ancillary panel sections, is engaged.

TTR and DR panel sections have been provided for future use. At present, only the tracking mode select displays are wired.

The ancillary panel contains five switches and two displays. One display monitors the "Ready" status of the DDH system and the other indicates that the "Computer" or Prediction Tracking Mode has been selected. A "Computer Ready" switch indicates the ready status of the computer complex to the Instrument Van Control Console.

1.8.2.2 Control Console Display. The control Console Display assembly displays five, five-digit decimal words which include a word identification character. The Display module is mounted on the top of the Instrument Van Control Console.

The five decimal words are generated by the computer, assembled and decoded in the Computer I/O Box, and the output is connected directly to the console display. The system is capable of displaying decimal degree azimuth and elevation command angle, position angle, and error angle data in addition to range data. Rear projection type, one plane, in-line readouts are utilized in the display assembly. A lamp brightness control is provided on the display assembly. The lamp power (+28vdc) taken from the 28 vdc supply is located in the Instrument Van rack 2A4.

1.8.2.3 TRADEX (COBI) Line Filter Box and Range Tape Mode Control. The TRADEX (or COBI) message is received from the range on 600 ohm telephone lines, terminated in standard low-pass filters, located in the computer screen room. Switching is provided for real time recording (Range Mode) of the TRADEX message. The recorded TRADEX message can also be reproduced (Tape Mode) to drive the system for simulation checkout.

Filter Box - The (TRADEX) COBI communication is terminated in a balanced 600 ohm line transformer. The transformer secondary is switch-fed to a low-pass filter in the Range (or Write) Mode and terminated into a 600 ohm load in the Tape (or Read) Mode. The filtered signal is then transferred to the TRADEX assembler and/or the Instrument Van recorder. The amplifier can either be set for unity or two depending on the switch position. Three channels are provided to filter the 1200 cycle TRADEX message. The passband of one filter is high enough to receive the 1500 cycle output of the COBI transmitter should it be necessary to include a COBI receiver in the system.

Range/Tape Mode Control - Referring to the simplified schematic shown in figure 1-31, the Range/Tape Mode is controlled by the Read/Write switch located on the Auxiliary Record Control Panel of Rack 2A5 in the Instrument Van. The reproduced data is switched to the Filter Box in the Tape (or Read) Mode and the range data is switched to the Filter Box, and record electronics, in the Range (or Write) Mode. The reproduced signal is driven by an amplifier located in I/O Interface Logic Case, 2A11A2.

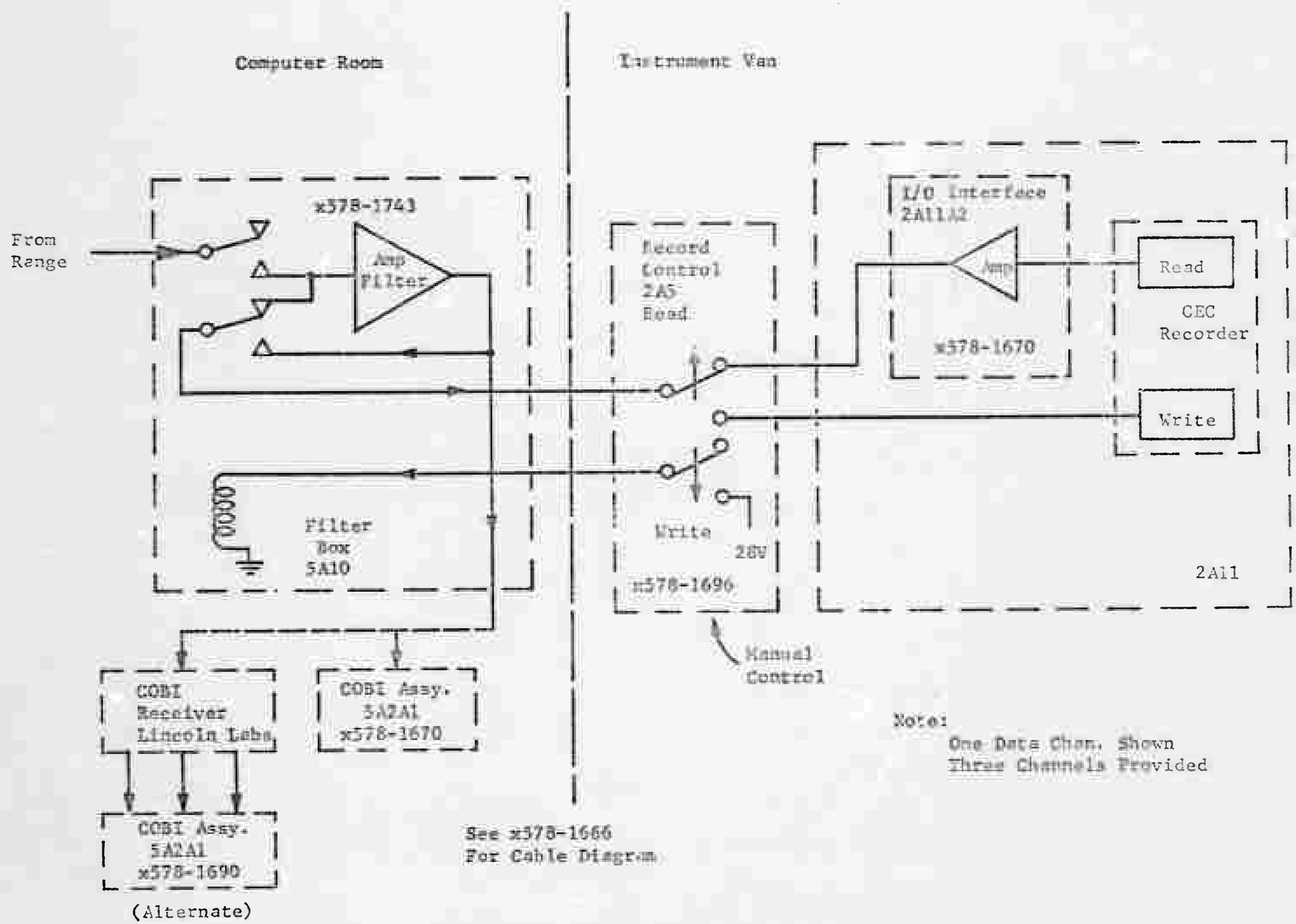


Figure 1-31. Range/Tape Mode Switching

1.8.2.4 DDH I/O Interface Logic Case. The I/O Interface Logic Case, located in the Instrument Van Rack 2A11, contains data receivers and cable drivers used for communication between the DDH system and the SDS 930 computer extension. It also contains relay circuits for remote control of the CEC recorder from the Instrument Van Control Console.

1.8.2.5 Control Word Assembler. The Control Word Assembler receives tracking mode information from the Instrument Van Control Console and track file information from the TRADEX (or COBI) Assembler. This information is assembled into a control word register for transfer to the Computer I/O Box. An interrupt pulse is generated and transmitted to the Computer I/O Box whenever a change occurs in the control word. Status information is also relayed to the Operator Consolette for display.

1.8.2.6 TRADEX (COBI) Message Assembler. Formatted Serial data is assembled in three 18-bit registers (X, Y and Z data), one for each coordinate. When the message is assembled, a ready and/or interrupt term goes true to signal the Computer I/O box to accept data. Three 18-bit parallel-words are transferred to the computer I/O Junction Box after formatting has been completed. The COBI serial data is tested for bit drop-out and sync error.

1.8.2.7 Pedestal Position Word Assembler (TTR Message Assembler). The pedestal position data is assembled in two (azimuth and elevation) 17-bit registers. When the data is assembled, a "Ready" term is applied to the sense line to signal the Computer I/O Box to accept the data.

Two 24-bit registers and one 16-bit register have also been provided for future use. These registers can be utilized for assembling TTR data when available.

1.8.2.8 Modification to DDH Tracking Data Subsystem. Serial azimuth and elevation data from the Computer I/O Box is transmitted to the DDH Command Angle Registers through the local radar inputs originally provided for that purpose. Because the original system was designed to receive range data in six-bit parallel format, the Range Register has been modified to accept serial range data from the Computer I/O Box. Kineplex range data cannot be recorded without modification of the logic to the original configuration.

1.8.3 Computer Equipment-Purchased

1.8.3.1 SDS 930 Computer. The SDS 930 computer consists of a 930 central processor, an 8K memory door, a Time Multiplexed Communication Channel (TMCC) with interlace, the basic interrupts, sixteen levels of priority interrupts with arming control, the computer control console, and a buffer junction box.

The 930 computer is a general purpose, solid state, digital computer with its basic format a 24-bit word plus a parity bit, and a machine cycle time of 1.75 microseconds. The TMCC with interlace enables input and output to and from peripheral equipment without requiring a separate instruction for each word. The priority interrupts enable synchronization of the computer with real time and facilitate the assembly and transposition of the tracking data. The Junction Box provides communication between the 930 computer, the Perkin-Elmer I/O box, and the DDH.

1.8.3.2 Peripheral Equipment. Peripheral equipment to the 930 computer consist of the following:

1. 35 KSR Teletypewriter

   The teletypewriter set transmits and receives, at the rate of 100 words/minute, page printed information to and from the computer by translating the information into a start-stop code.

2. Paper tape station (reader and punch)

   The REMEX Tape reader photoelectrically reads paper tape at the rate of 300 characters/sec.

   The Tally tape punch is an electrically operated high-speed unit capable of perforating paper tape at rates of up to 60 characters/sec.

   The tape reader and punch act as the main software input/output device to the computer.

3. Model 95462 Magnetic Tape Unit

   This magnetic tape unit provides read and write functions on 1/2" tape at an operating speed of 75 ips. It employs a vacuum buffering system for isolation of the driven tape from the storage reel, and a pressure system to prevent the tape from touching the guiding surfaces.

1.8.3.3 On-Site Programming. The SDS 930 computer with its peripheral equipment, as outlined above, permits on-site programming. With this software capability, along with the associated junction and input/output hardware, a complete on-site checkout of the GLOW system can be performed. This acts as an invaluable aid in maintaining the system in an operational state.

For a detailed technical and operational description of the above equipment, refer to the proper reports listed in the bibliography.

1.8.4 GLOW Computer Programming

The software developed for project GLOW is (1) the real-time operational program, and (2) the special purpose calibration and simulation programs.

1.8.4.1 Real-Time Program - Logic Flow. The flow of the GLOW real-time program depends on the status of the three "interrupts" system.

At the start of the program, the main routine calls "Subroutine GLOW". The functions of the routine are as follows:

1. Initialization of various constants.
2. Set up interrupts (arming the interrupts).
3. Waits for the occurrence of the interrupts.

When the first level interrupt occurs (the first level interrupt occurs every 25 milliseconds (ms) continuously during the mission), without disturbing the program counter register, the computer transfers program control to memory location 200. The "BRM DATA" instruction in this location branches the flow to SUBROUTINE DATA. This routine controls the major portion of this program. The functions of this routine are as follows:

1. It outputs AZ, EL, R to DDH system
2. It checks various SKS's ready-not-ready signal.
3. In computer track mode, it calls the prediction routine to generate AZ, El, R data to track the vehicle.
4. It updates the display counter so the program can update the digital display every 500 ms.
5. It calculates five data points (up to 120 points of prediction available) for AZ, EL, and R. These data points are used until the system gets new COBI message at approximately 100 ms. This portion calls "SUBROUTINE KADKIA" for trajectory calculations to output command information into the DDH every 25 ms.
6. It keeps track whether system missed COBI messages or not and, depending on that status, it changes the display mode.
7. It gets new Pedestal position AZ and position EL, respectively, from DDH System. If Pedestal SKS is not ready, the routine sits idle and waits for its readiness to get AZ, EL.
8. It clears the first level interrupt so the lower level interrupts can be processed for further actions. SUBROUTINE DATA calls, directly or indirectly, routines "UPDATE", "COMPUT", and "KADKIA".

When COBI message is ready, the second level interrupt may occur if it is in waiting status. The arrival of this type of interrupt transfers control to memory location 201; the "BRM COBIGO" instruction branches the flow to this routine. This routine sets up flags to whatever "DATA" routine checks the status of the flags. It then gets new X, Y, Z coordinates from COBI message. It also clears this interrupt so that if the third level interrupt is in Waiting Status, then that interrupt gets its turn, etc.

Figures 1-32 through 1-36 detail the SUBROUTINES flow diagrams of the realtime program listed above.

The following summarizes the coded routines used to gather signature data from reentry vehicles at Kwajalein Atoll:

1) MAIN PROGRAM , FORTRAN language dummy main program.
2) Routine GLOW , Meta-Symbol language routine sets up interrupts.
3) Routine MODI , Examines the status of the console mode.
4) Routine COBIGO , Signals for the COBI message's arrival.
5) Routine DATA , Central routine which governs the function of other routines, etc.
6) Routine COLLE , Collects last 120 points and updates those points.
7) Routine KADKIA , Does the trajectory computation.
8) Routine UPDATE, , Updates the digital display on the console.
9) Routine BID , Converts R into 6 bits character BCD word.
10) Routine PREBID , Converts 6 bits character word into 4 bits character for digital display.
11) Routine CNVTDI , Converts AZ, R into degrees.
12) Routine ATN , Fix-pt. Arc-tangent routine.
13) Routine DSQ , Fix-pt. double precision square-root routine.
14) Routine COMPUT , Prediction routine.
15) Routine POLYFIT , Parabolic evaluation routine.
16) Routine LSQR , Least-square routine.
17) Routine PLKSQR , Floating pt. square root routine which finds sq. root from common location (it is not a function).

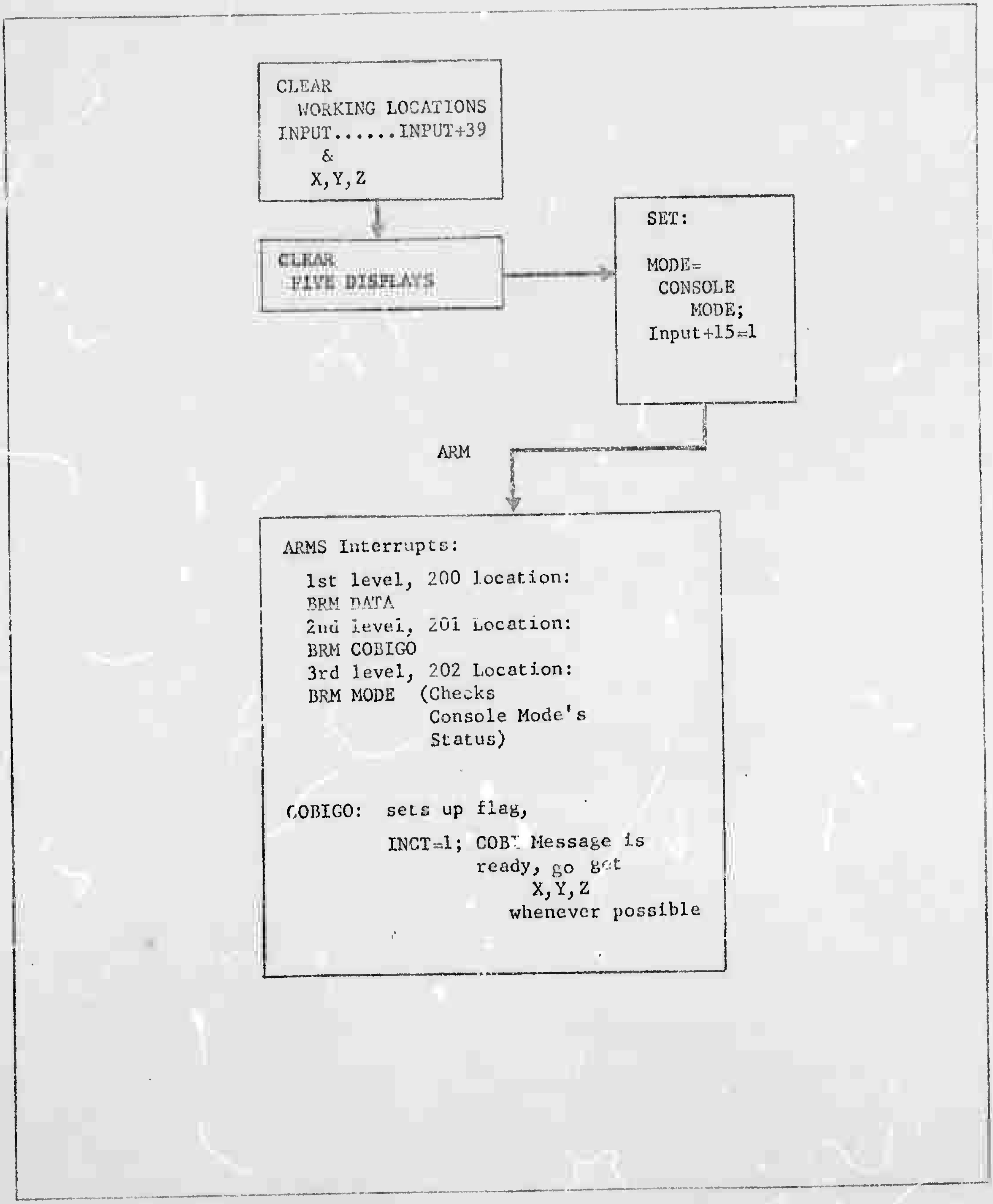


Figure 1-32. Subroutine GLOW

This routine is executed every 25 ms.

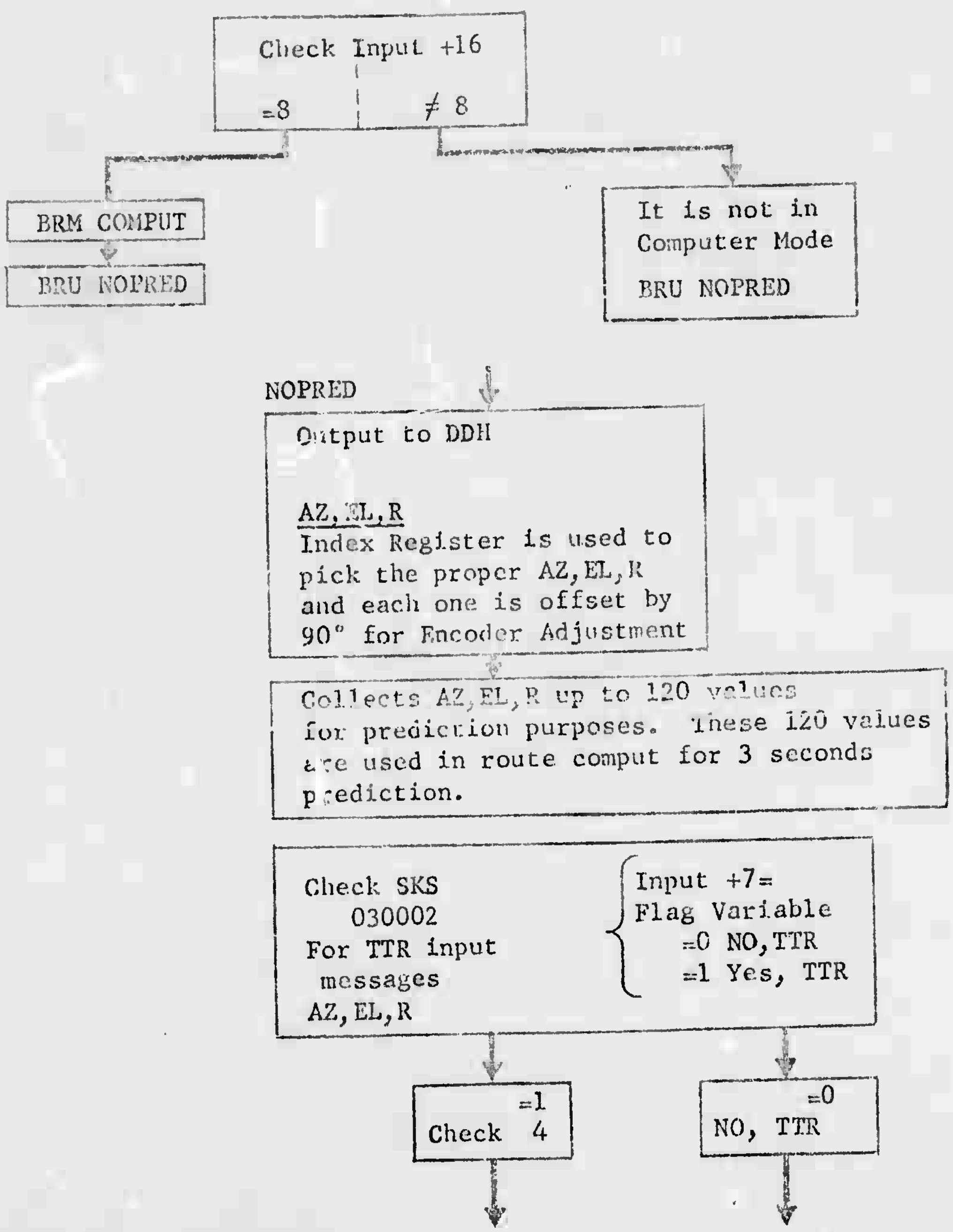


Figure 1-33. Subroutine DATA (Sheet 1 of 4)

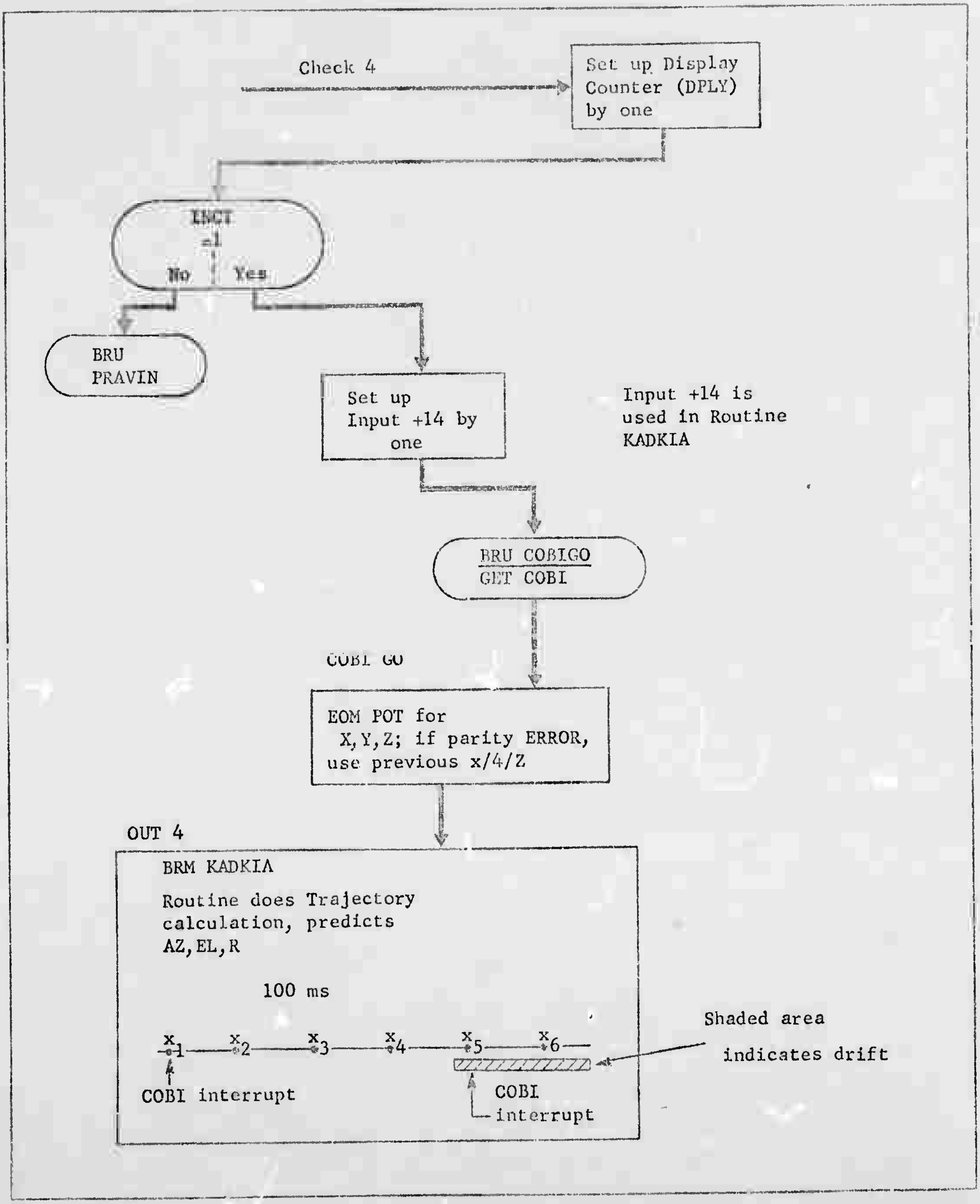


Figure 1-33. Subroutine DATA (Sheet 2 of 4)

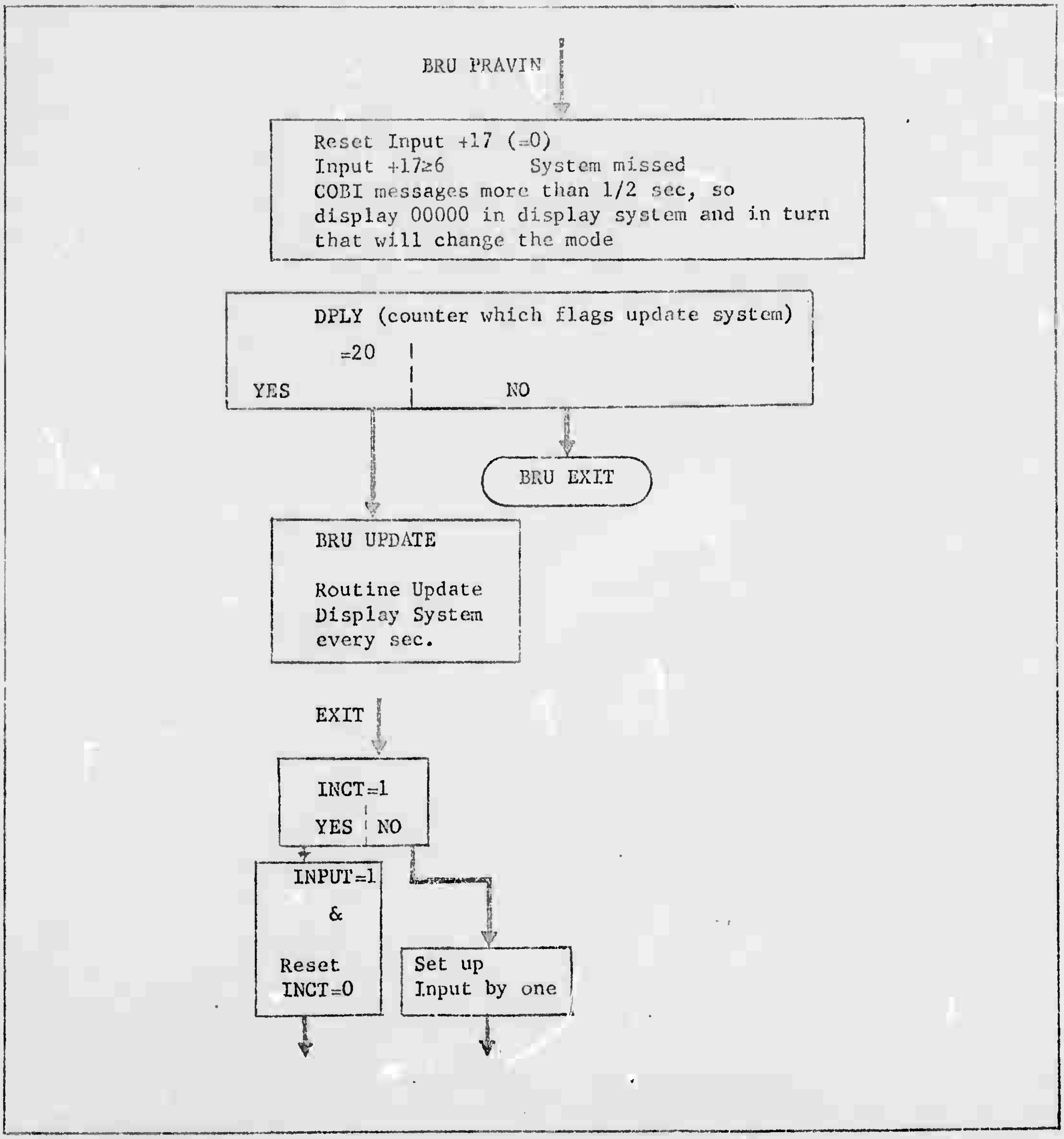


Figure 1-33. Subroutine DATA (Sheet 3 of 4)

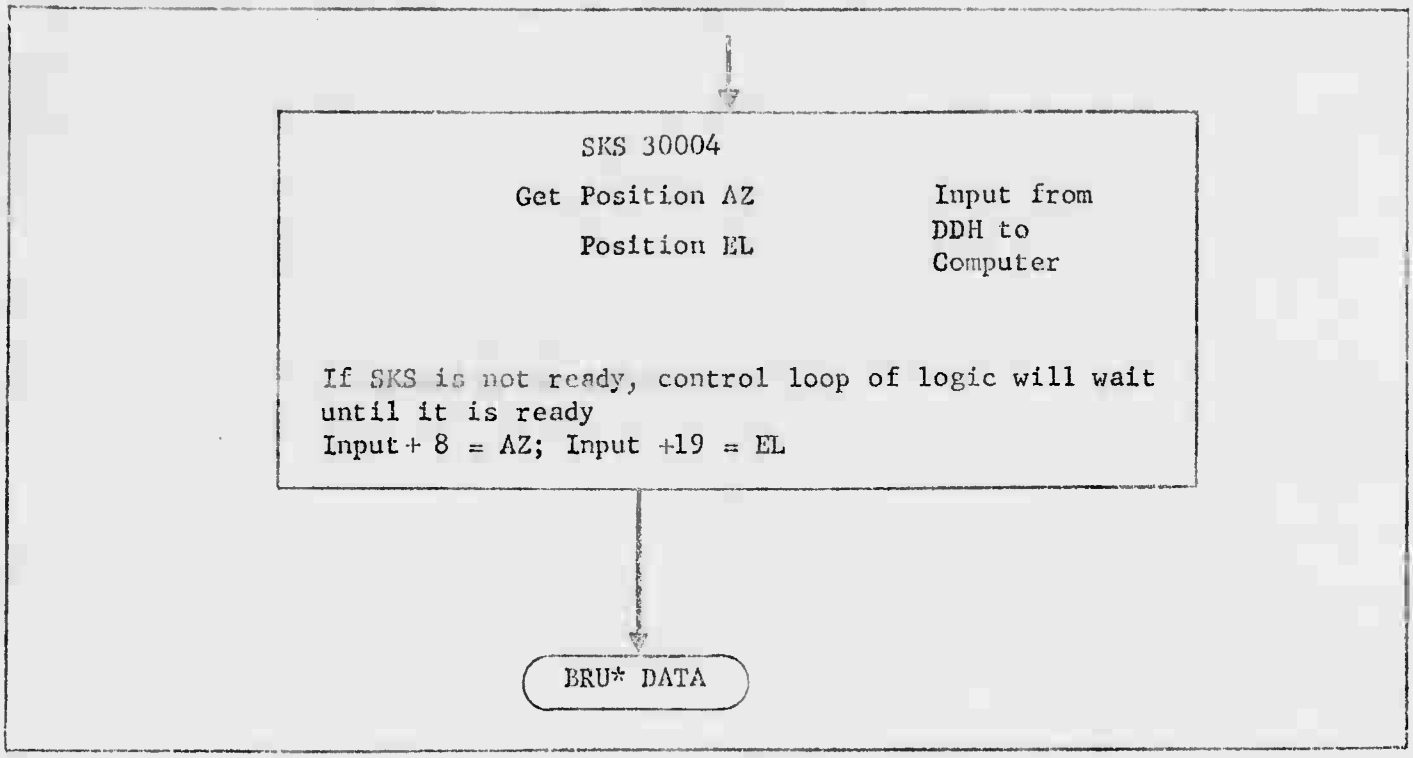


Figure 1-33. Subroutine DATA (Sheet 4 of 4)

This routine predicts COBI X,Y,Z between two successive COBI messages

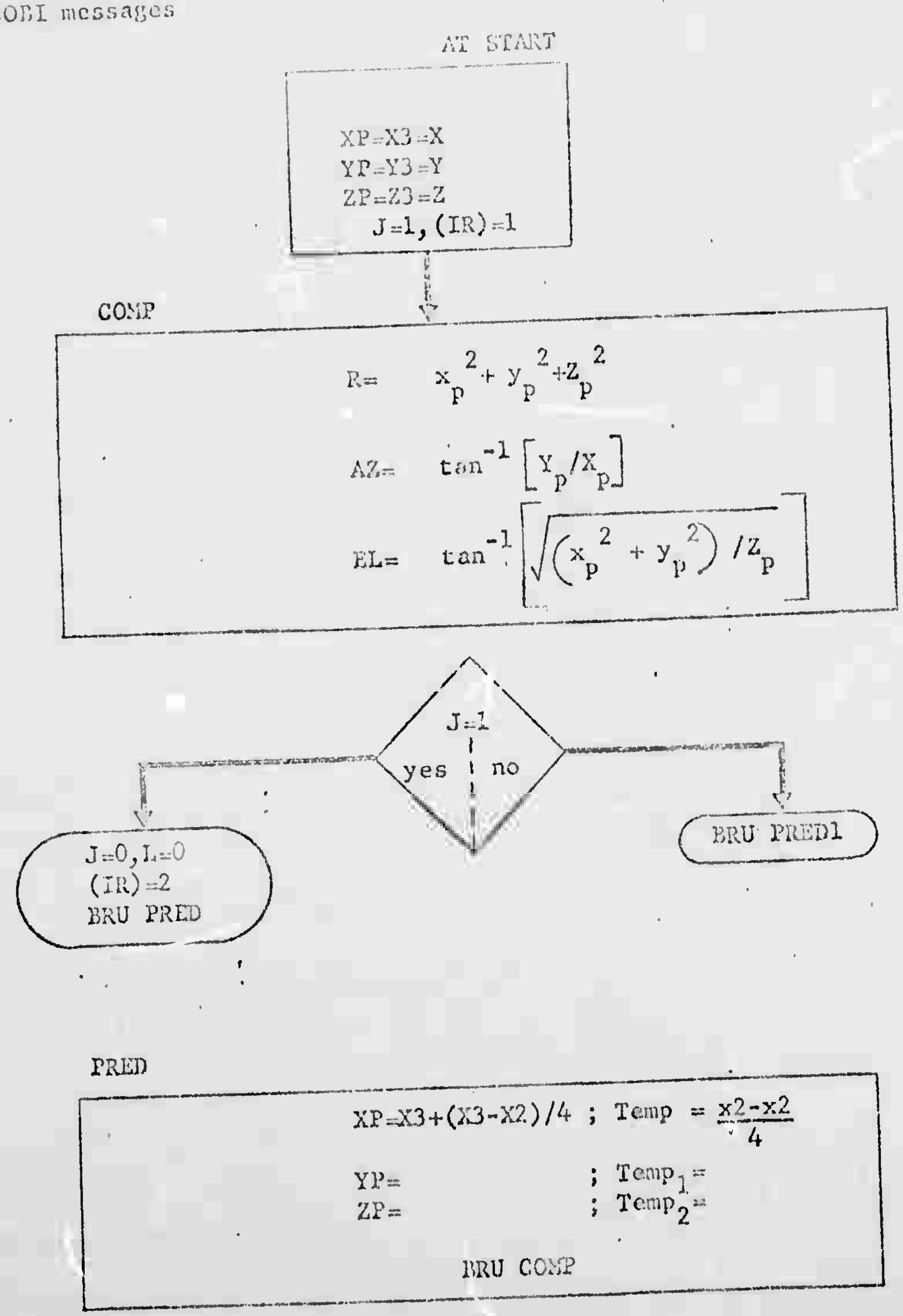


Figure 1-34. Subroutine KADKIA (Sheet 1 of 2)

PREDI

L=L+1

L≤3

(IR) = L+2
XP=XP+TEMP
YP=YP+Temp 1
ZP=ZP + Temp 2

BUR COMP

L>3

X2=X3; Y2=Y3; Z2=Z3
X1=X2;Y1=Y2;Z1=Z2

OUT FROM THE ROUTINE

So it predicts 5 points ahead of next incoming Cobi message.
Prediction to 120 points is possible by change in constant
(L3 in location 1453)

AZ_1	EL_1	R_1
AZ_2	EL_2	R_2
AZ_3	EL_3	R_3
AZ_4	EL_4	R_4
AZ_5	EL_5	R_5

Figure 1-34. Subroutine KADKIA (Sheet 2 of 2)

The function of the routine is to update digital display according to the status of the variable STATE.

=1,2,3,4 Display in Track-File Mode (not assigned)
=5 Display in TTR Mode (not assigned)
=6 Display in COBI MODE
=7 Display in CONSOLE MODE
=8 Display in Compute Mode
=9 I/R Mode, same as 8
=10 I/O Mode, same as 8
=11 Manual Mode, same as 8
=12 Display in B-50 Mode
Otherwise Display in DR, MODE (not assigned)

This routine calls "CNVTDI" and "PREBID", respectively. The "CNVTDI" routine converts binary (AZ, EL) to BCD for display read-out. At this point, AZ, EL are in fraction of circle, so the routine first converts into degrees and four bits BCD characters simultaneously. The "PREBID" routine converts Range (R) into four bits BCD characters for display. It displays in Kilometer.

Figure 1-35. Subroutine UPDATE

This routine is completely coded in FORTRAN II language. The listing has many remark-cards for explanation purposes.

It fits parabola to AZ,EL respectively such as

$$AZ=a+bt+ct^2$$

$$EL=d+et+ft^2$$

and calculates the parameters a,b,c,d,e,f in Least-Square since using 120 points and predicts the 121st point. Again, using last 120 points, it predicts 121st points, etc, for 3 seconds if the missile or vehicle is lost or under cloud.

This routine call the following routines:

1) POLYFIT
2) LSQR
3) PLKSQR

for computational purposes.

Figure 1-36. Subroutine COMPUT

1.8.4.2 Special Purpose Calibration Programs. The programs described below have been developed to verify computer subsystem operation and/or maximize GLOW system tracking performance:

1. The RAMP, STEP, and PARABOLA programs are utilized for closed loop evaluation of the GLOW tracking system.
2. The TEST BOX routine verifies system data transfer from the computer through all operational registers.
3. The COBI PIN IN program facilitates the dumping of a TRADEX or real-time message, verifying the communication system prior to a mission.
4. The DISPLAY routine tests and verifies the operation of the Control Console Display located in the Instrument Van.
5. The FLEXOWRITER routine is the simulation of a flexowriter to assemble any program on paper tape. A description of the program is given in figures 1-37 through 1-43.
6. The GLOW DUMP routine is also available for listing the complete block format, recorded in the Instrument Van, during checkout and mission.

Purpose: To provide a variable ramp function for servo testing.

Location: 660 to 1120.

Loading: Use normal fill procedure for paper tape.

Breakpoints: BPT1: reset - input position angles.
set - output command angles.
BPT2: reset - no effect.
set - output ramp.
To restart program - reset all breakpoints and idle - start - step - run.

Procedure: Load program - move pedestal to desired starting position - set BPT1 to output position angle as command angle. Lock pedestal in loop - pick ramp from switches on test box (table I) - set BPT2 to output ramp. To change time period of ramp store, count in Loc 1050 as indicated in table I.

TABLE I

°/sec	Switches	Loc 1050 AZ TIME		Loc 1050 EL TIME	
		Sec	Count	Sec	Count
2	0-1-4	20	1440	10	620
5	1-3-5	20	1440	10	620
10	0-1-3-4-6	10	620	7	430
15	2-7	10	620	5	310
20	1-2-4-5-7	10	620	9	240
25	2-5-6-7	8	500	3	170

PROGRAM LISTING

ADDRESS	INSTRUCTION	ADDRESS	INSTRUCTION	ADDRESS	INSTRUCTION
660	LDA 671	670	BRU 700	700	LDA 735
1	STA 1	1	BRU 660	1	STA 200
2	LDA 1030	2	PZE	2	BRU 703
3	STA 1043	3	PZE	3	EOM 30500
4	LDA 1031	4	PZE	4	PIN 740
5	STA 1046	5	PZE	5	EOM 30600
6	CLA	6	PZE	6	PIN 741
7	STA 1051	7	PZE	7	EOM 31001

Figure 1-37. RAMP Program (Sheet 1 of 2)

PROGRAM LISTING (Continued)					
ADDRESS	INSTRUCTION	ADDRESS	INSTRUCTION	ADDRESS	INSTRUCTION
710	PIN 742	1010	LDA 1032	1060	LDA 740
1	BPT 1	1	STA 1043	1	MRG 1067
2	BRU 1052	2	LDA 1033	2	STA 740
3	BRU 703	3	STA 1046	3	LDA 741
4	NOP	4	BRU 1110	4	MRG 1067
5	EOM 31200	5	NOP	5	STA 741
6	POT 740	6	NOP	6	BRU 715
7	EOM 32001	7	NOP	7	77400000
720	POT 741	1020	LDA 1033	1070	LDA 740
1	EOM 32002	1	STA 1043	1	ETR 1105
2	POT 740	2	LDA 1030	2	ADD 742
3	AIR	3	STA 1046	3	STA 740
4	POT 737	4	BRU 715	4	LDA 741
5	EIR	5	NOP	5	ETR 1105
6	BRU 726	6	NOP	6	ADD 742
7	NOP	7	NOP	7	STA 741
730	LDX 736	1030	BRU 771	1100	BRU 1060
1	LDA 736	1	BRU 1000	1	NOP
2	BRX 731	2	BRU 1010	2	NOP
3	DIR	3	BRU 1020	3	NOP
4	BRU* 776	4	NOP	4	NOP
5	BRU 730	5	NOP	5	00377777
6	00077615	6	NOP	6	NOP
7	00377777	7	NOP	7	NOP
770	BRU 703	1040	MIN 1051	1110	LDA 740
1	LDA 1030	1	LDA 1051	1	ETR 1105
2	STA 1043	2	SKE 1050	2	SUB 742
3	LDA 1031	3	BRU 771	3	STA 740
4	STA 1046	4	CLA	4	LDA 741
5	BRU 1070	5	STA 1051	5	ETR 1105
6	BRU 711	6	BRU 1000	6	SUB 742
7	PZE	7	NOP	7	STA 741
1000	LDA 1031	1050	NOP	1020	BRU 1060
1	STA 1043	1	NOP		
2	LDA 1032	2	BPT2		
3	STA 1046	3	BRU 1055		
4	BRU 715	4	BRU 1060		
5	NOP	5	EOM 31001		
6	NOP	6	PIN 742		
7	NOP	7	BRU 1040		

Figure 1-37. RAMP Program (Sheet 2 of 2)

Purpose: To provide a variable continuous step function for servo testing.

Location: In memory 0660 to 1157.

Loading: Use normal fill procedure for paper tape.

Breakpoints:
BPT1: reset - input position angles.
set - output command angles.
BPT2: reset - no effect.
set - output step function.
To restart program - reset all breakpoints and idle - start - step - run.

Procedure: Load program, move pedestal to desired starting position - set BPT1 to output position angle as command angle. Lock pedestal in loop - pick step from switches on test box (table I of Figure 1-37) - set BPT2 to output step.
To change period of step store, count in Loc 1150.
1 count = 25 ms · Count is set for 10 sec.
40_{10} = 1 sec.

PROGRAM LISTING

ADDRESS	INSTRUCTION		ADDRESS	INSTRUCTION		ADDRESS	INSTRUCTION	
660	LDA	672	710	PIN	742	770	BRU	703
1	STA	1	1	BPT	1	1	LDA	1030
2	LDA	1030	2	BRU	1052	2	STA	1043
3	STA	1043	3	BRU	703	3	LDA	1031
4	LDA	1031	4	NOP		4	STA	1046
5	STA	1046	5	EOM	31200	5	BRU	1070
6	CLA		6	POT	742	6	NOP	
7	STA	1051	7	EOM	32001	7	NOP	
670	STA	1151	720	POT	741	1000	LDA	1031
1	BRU	700	1	EOM	32002	1	STA	1043
2	PZE		2	POT	740	2	LDA	1032
3	PZE		3	AIR		3	STA	1046
4	PZE		4	POT	737	4	BRU	1130
5	PZE		5	EIR		5	NOP	
6	PZE		6	BRU	726	6	NOP	
7	PZE		7	NOP		7	NOP	
700	LDA	735	730	LDX	736	1010	LDA	1032
1	STA	200	1	LDA	736	1	STA	1043
2	BRU	703	2	BRX	731	2	LDA	1033
3	EOM	30500	3	DIR		3	STA	1046
4	PIN	740	4	BRU*	776	4	BRU	1110
5	EOM	30600	5	BRU	730	5	NOP	
6	PIN	741	6	00077615		6	NOP	
7	EOM	31001	7	00377777		7	NOP	

Figure 1-38. STEP Program (Sheet 1 of 2)

PROGRAM LISTING (Continued)					
ADDRESS	INSTRUCTION	ADDRESS	INSTRUCTION	ADDRESS	INSTRUCTION
1020	LDA 1033	1070	LDA 740	1140	PZE
1	STA 1043	1	ETR 1105	1	CLA
2	LDA 1030	2	ADD 742	2	STA 1151
3	STA 1046	3	STA 740	3	LDA 1147
4	BRU 1130	4	LDA 741	4	STA 1051
5	NOP	5	ETR 1105	5	BRU 715
6	NOP	6	ADD 742	6	PZE
7	NOP	7	STA 741	7	00000001
1030	BRU 771	1100	BRU 1060	1150	00000600
1	BRU 1000	1	PZE	1	PZE
2	BRU 1010	2	PZE		
3	BRU 1020	3	PZE		
4	NOP	4	PZE		
5	NOP	5	00377777		
6	NOP	6	PZE		
7	NOP	7	PZE		
1040	MIN 1051	1110	LDA 740		
1	LDA 1051	1	ETR 1105		
2	SKE 1050	2	SUB 742		
3	BRU 771	3	STA 740		
4	LDA 1147	4	LDA 741		
5	STA 1051	5	ETR 1105		
6	BRU 1000	6	SUB 742		
7	NOP	7	STA 741		
1050	PZE	1120	BRU 1060		
1	PZE	1	PZE		
2	BPT 2	2	PZE		
3	BRU 1055	3	PZE		
4	BRU 1060	4	PZE		
5	EOM 31001	5	PZE		
6	PIN 742	6	PZE		
7	BRU 1040	7	PZE		
1060	LDA 740	1130	LDA 1151		
1	MRG 1067	1	SKG 1150		
2	STA 740	2	BRU 1134		
3	LDA 741	3	BRU 1141		
4	MRG 1067	4	MIN 1151		
5	STA 741	5	CLA		
6	BRU 715	6	STA 1051		
7	77400000	7	BRU 715		

Figure 1-38. STEP Program (Sheet 2 of 2)

Purpose: To provide acceleration rates for GLOW servo system testing by outputting a parabolic function as the command angle.
There is a choice of fourteen parabolic functions (seven for each axis as listed in table I). The position angle is inputted to the computer; a parabolic function is developed using this angle as its starting and finishing point. The curve is then outputted to the DDH as the command angle.

TABLE I

$^o/_{sec^2}$	CONSTANTS	
	AZ	EL
3	AØ3	EØ3
5	AØ5	EØ5
10	A10	E1Ø
15	A15	E15
20	A2Ø	E2Ø
30	A3Ø	E3Ø
40	A4Ø	E4Ø

Break Point Settings:

BPT1: reset - input position angle.
set - output command angle.
BPT2: reset - output parabolic function.
set - output static point, reinitialize.
BPT3: reset - no function.
set - develop parabola.

Loading: Normal fill procedure for paper tape.

1) Type constants from table I for choice of parabola desired followed by a carriage return.
2) Move pedestal to desired starting position.
3) Set BPT3 (develop parabola based on pedestal position as starting and finishing point).

3a) Reset BPT 3.

4) Clear halt.
5) Set BPT 2 (initialize).
6) Set BPT 1 (output starting point).
7) Lock servo in the radar loop.
8) Reset BPT2, when desired, to output the parabolic function.

To restart program:

Idle, start, step, run.

NOTE: To create parabola, every 50 ms a new command angle is outputted. To slow down the acceleration, change the count in LOC 1071, 1 count = 25 ms.

Figure 1-39. PARABOLA Program

Purpose: To output command angles to the DDH for static check-out.

Location: 200 - 237.

Loading: Use normal fill procedure.
To start program BRU to 200.

Procedure: Start program and use the switches on the test box to set up the desired command angle. Observe the angle in the command angle register of the DDH.
Have switches 0 through 6 switched to the one position.

PROGRAM LISTING

ADDRESS	INSTRUCTION	ADDRESS	INSTRUCTION
200	BRU 220	220	LDX 232
1	BRU 202	1	LDA 232
2	EOM 31001	2	BRX 221
3	PIN 226	3	DIR
4	NOP	4	BRU 201
5	EOM 31200	5	PZE
6	POT 226	6	PZE
7	EOM 32001	7	PZE
210	POT 226	230	00377777
1	EOM 32002	1	PZE
2	POT 226	2	00077615
3	AIR	3	PZE
4	POT 230	4	PZE
5	EIR	5	PZE
6	BRU 216	6	PZE
7	NOP	7	PZE

Figure 1-40. TEST BOX Program

<u>Purpose</u>: To test the COBI assembler by inputting X, Y, & Z data into the computer and dumping it out on the typewriter using "AID".

<u>Location</u>: 16000 to 16037.

X data 1000 to 1777
Y data 2000 to 2777
Z data 3000 to 3777

<u>Loading</u>: Load program using normal fill procedure; then load "AID" into "10000".
To restart program BRU to 16000.

<u>Procedure</u>: Input COBI Data into the assembler via the COBI receiver or the CEC tape. Start program when desired data is being inputted to the assembler.
After data is inputted, the typewriter will be enabled, and, using "AID," dump out the desired X, Y, and Z data.

PROGRAM LISTING

ADDRESS	INSTRUCTION		ADDRESS	INSTRUCTION	
16000	EOM	20004	16030	PIN	1000
1	LDX	16034	1	PIN	2000
2	SKS	30001	2	PIN	3000
3	BRU	16005	3	PZE	
4	BRU	16002	4	00077700	
5	EOM	30401	5	PZE	
6	PIN	1000	6	PZE	
7	EOM	30402	7	PZE	
16010	PIN	2000			
1	EOM	30404			
2	PIN	3000			
3	EOM	32004			
4	MIN	16006			
5	MIN	16010			
6	MIN	16012			
7	BRX	16002			
16020	LDA	16030			
1	STA	16006			
2	LDA	16031			
3	STA	16010			
4	LDA	16032			
5	STA	16012			
6	BRU	10000			
7	PZE				

Figure 1-41. COBI PIN IN Program

Purpose: To test the decimal display.

Location: 50 to 67.

Loading: Use normal fill procedure.
To restart program BRU to 50.

Procedure: Start the program. On the test box, set up the desired number to be displayed. This number will be outputted to all five decimal displays.

PROGRAM LISTING

ADDRESS	INSTRUCTION	
50	EOM	31001
1	PIN	70
2	EOM	31004
3	POT	70
4	EOM	31010
5	POT	70
6	EOM	31020
7	POT	70
60	EOM	31040
1	POT	70
2	EOM	31100
3	POT	70
4	BRU	50
5	PZE	
6	PZE	
7	PZE	

Figure 1-42. DISPLAY ROUTINE Program

```
C  SIMULATION OF FLEXOWRITER ON GLOW PROJECT  SDS 930 K.SAKIA
C
C        M = 0    LIST AND PUNCH  N  LINES.
C
C          = 1    LIST  N  LINES ONLY.
C
C          = 2  FLEXOWRITER OF ANY NO. OF LINES[TYPEWRITER-PUNCH]
C
C          = 3    DELETE  N  LINES ONLY.
C
C          =  4  REPRODUCER
C
C          =  5  FLEXOWRITER-----  N LINES ONLY.
C
         DIMENSION KARD[80]
          GO TO 30
C
            FLEXOWRITER .......
C
 55       K=1
 1       ACCEPT 101,KARD
 101     FORMAT[80A1]
         DO 20 I=80,1,-1
        IF[KARD[I] - ISUM] 10,20,10
 20      CONTINUE
         GO TO 1
 10      PUNCH TAPE 101,[KARD[J],J=1,I]
          IF[M-5] 1,56,1
 56       K=K+1
          IF[K-N] 1,1,30
          GO TO 30
C
C
 30        ACCEPT 31,M,N
C
C        TYPE CONTROL CODE.
C
 31        FORMAT[2I5]
           GO TO [32,40,1,33,40,55], M+1
C
C  ---------  LIST + PUNCH  OR  DELETE  ------
C
```

Figure 1-43. Simulation of Flexowriter on GLOW (Sheet 1 of 2)

```
 32      DO 34 I=1,N
         ACCEPT TAPE 101,KARD
         DO 200 L=80,1,-1
         IF[KARD[L] - ISUM] 100,200,100
 200     CONTINUE
         GO TO 34
 100     PUNCH TAPE 101,[KARD[K],K=1,L]
         TYPE 101,[KARD[K],K=1,L]
 34      CONTINUE
         GO TO 30
 33      DO 35 I=1,N
         ACCEPT TAPE 101,KARD
 35      CONTINUE
         GO TO 30
 40      DO 42 I=1,N
 C
 C  --------  LIST  OR  REPRODUCER   --------
 C
         ACCEPT TAPE 101,KARD
         DO 43 L=80,1,-1
         IF[KARD[L] - ISUM] 44,43,44
 43      CONTINUE
 44      GO TO[50,50,50,51],M
 51      PUNCH TAPE 101,[KARD[J],J=1,L]
         GO TO 42
 50      TYPE 102,I,[KARD[J],J=1,L]
 102     FORMAT[ $=$,1X,I3,2X,80A1]
 42      CONTINUE
         GO TO 30
 C
 C  THANKS TO MR. ROBERT CURTIS FOR HIS  HELP.
 C
 C  GOOD BYE.....BYE....
 C
        END
```

PROGRAM ALLOCATION

```
 00000 KARD     00120 K      00121 I      00122 ISUM
 00123 J        00124 M      00125 N      00126 L
```

THE END

Figure 1-43. Simulation of Flexowriter on GLOW (Sheet 2 of 2)

SECTION II

INSTALLATION

2.1 CONTRACT AIM - INTRODUCTION

The installation and integration of one (1) GLOW system on Kwajalein Test Site (KTS), Kwajalein, Marshall Islands Trust Territory (figure 2-1), was awarded to the Perkin-Elmer Corporation under Contract No. DA-19-020-AMC-0265(Z).

The stated aims of the contract were:

1. To install one (1) GLOW system.
2. To interface the GLOW system with the required facilities of KTS.
3. To demonstrate GLOW system performance.

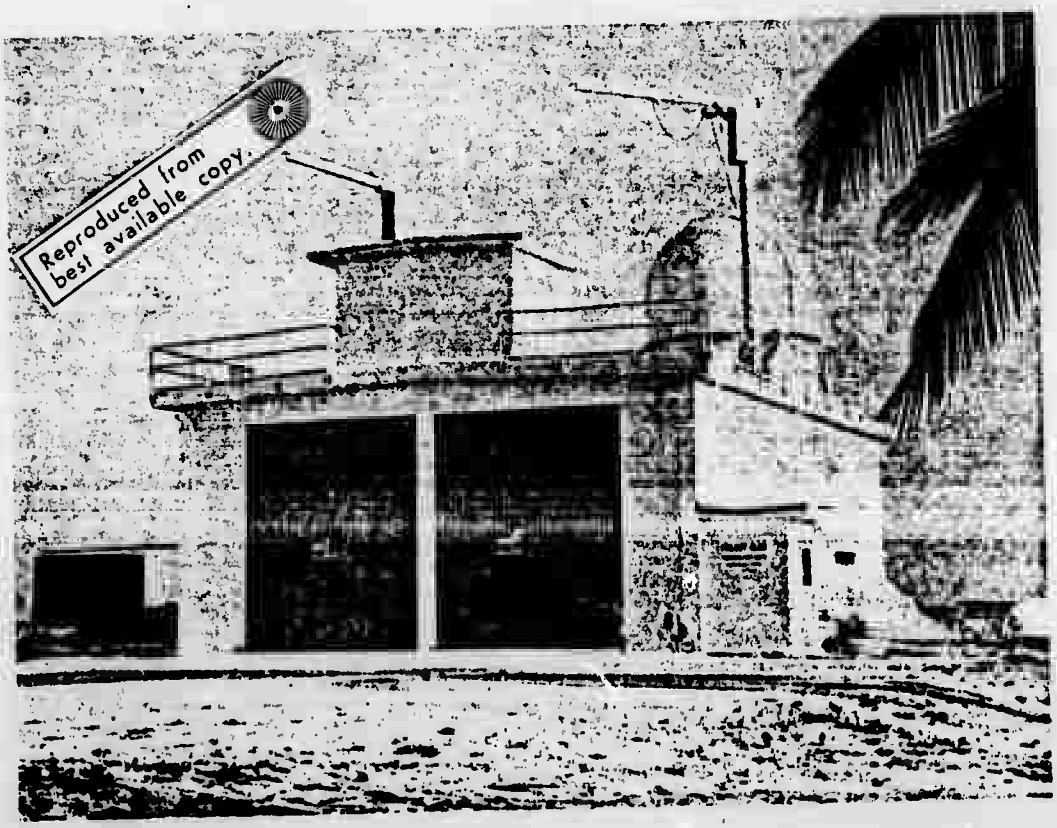


Figure 2-1. GLOW System at Kwajalein Test Site

2.2 SUMMARY

The installation of the GLOW system covered the period from 10 October, 1966 to 4 April, 1967 when System operation and inventory transfer was accepted by the Army Missile Command.

In fulfillment of this contract, the Perkin-Elmer effort encompassed the following tasks:

1. Preparation and transportation of System equipment and personnel. Equipment weight and volume exceeded 80,000 lbs. and 15,000 ft^3.
2. Preparation of the GLOW building (figure 2-2).
3. Emplacement of System equipment.
4. Preparation of equipment to operational status.
5. Interfacing of GLOW System to the required KTS communication, timing, and COBI facilities.
6. Demonstration of System performance.
7. Transfer of System operation and equipment.

Installation difficulties resulted primarily from the following:

1. Delays in equipment arrival caused by misplaced shipments at the Oakland and Travis Air Force Base transportation terminals and rescheduling of vessels and sailing dates.
2. Lack of an assigned vehicle to Project GLOW until mid-December; movement of personnel and required support equipment was dependent upon local transportation which was inadequate and time consuming.
3. Difficulties in processing necessary work orders by KTS facilities caused by conflicting contract support interpretation.
4. An extended rainy season in December and through mid-January with the subsequent rescheduling of KTS heavy equipment, cranes, fork lifts, etc.
5. Contractual clarification concerning Range communications and TRADEX lines, in support of Project GLOW, delayed the installation of the necessary external cabling until the last two weeks. Checkout of the interface was started and will be continued by the operating contractor.

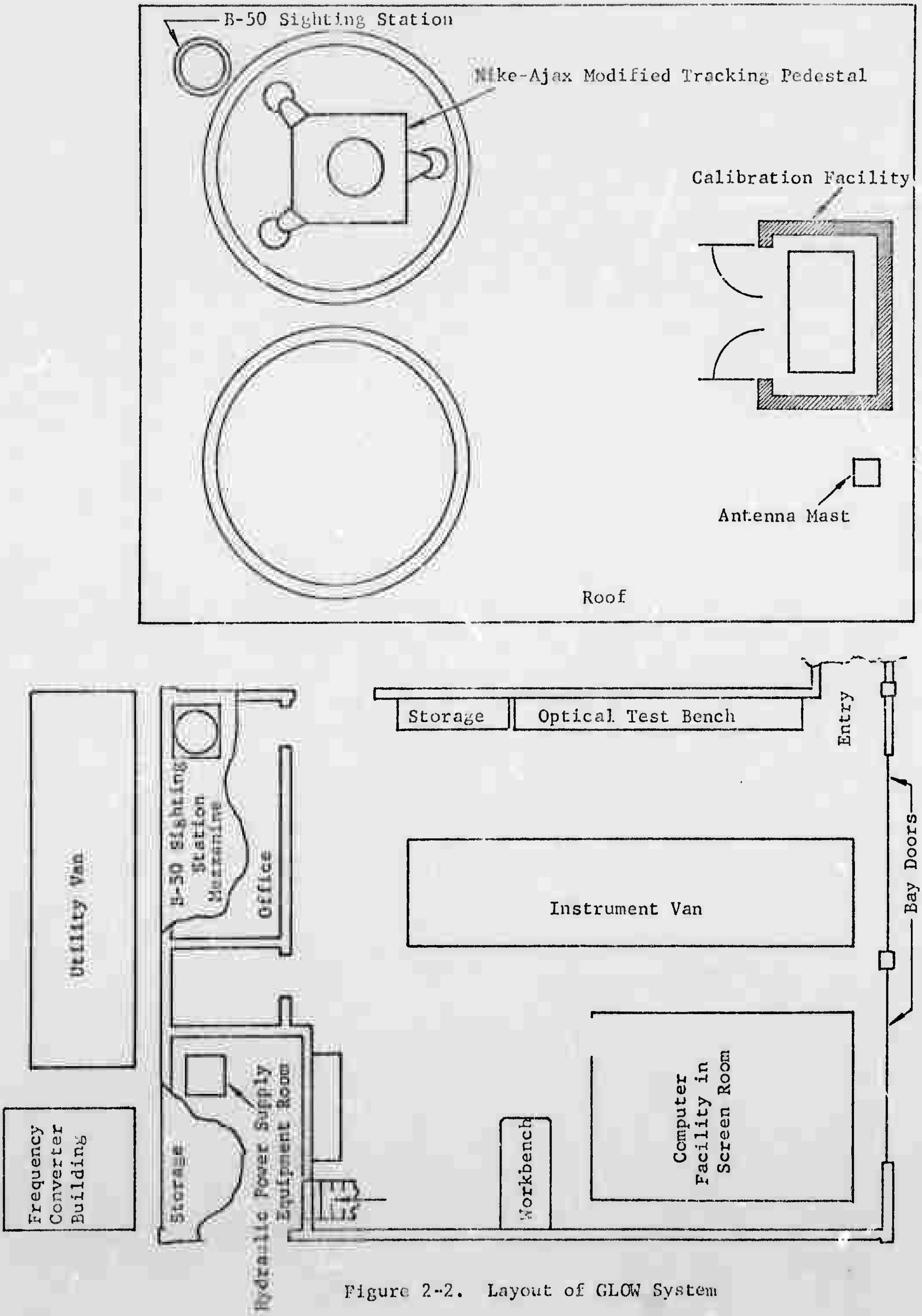


Figure 2-2. Layout of GLOW System

2.3 ORGANIZATIONAL SUMMARY

The organizational chart of Perkin-Elmer field and in-plant support personnel is shown in figure 2-3.

2.4 TRANSPORTATION OF EQUIPMENT

The GLOW equipment was divided into four groups for shipment so that site preparation and preliminary equipment installation could proceed at KTS, while the computer interfacing was being accomplished during the same period at Norwalk, Connecticut.

Transportation from Norwalk was entirely by Government Bill of Lading and utilized commercial transportation to the Port of Entry (POE) and Military or Military chartered vessels from the POE to KTS.

2.4.1 Transportation Summary

The transportation summary is given in Table 2-1.

TABLE 2-1. - TRANSPORTATION SUMMARY

Designation	Description	
Group I	Instruments, Test Equipment, Screen Room, Cables, Utility Van with tools, Astrodome, Shop Materials	
Group II	GLOW Mount, Frequency Converter, Cables, and Miscellaneous Materials	
Group III	Instrument Van, Cables, and Miscellaneous Materials	
Group IV	SDS Computer and Ancillary Equipment	
	Scheduled (actual) Norwalk	to Scheduled (actual) KTS
Group I	12 Sept.'66 (12 Sept.'66)	10 Oct.'66 (22 Oct.'66 and Nov. 9 '66)
Group II	17 Oct.'66 (18 Oct.'66)	10 Nov.'66 (9 Nov.'66 and 5 Jan. '67)
Group III	12 Nov.'66 (28 Oct.'66)	10 Dec.'66 (5 Jan.'67)
Group IV	17 Nov.'66 (12 Nov.'66)	10 Dec.'66 (10 Dec.'66 and 4 Jan.'67)

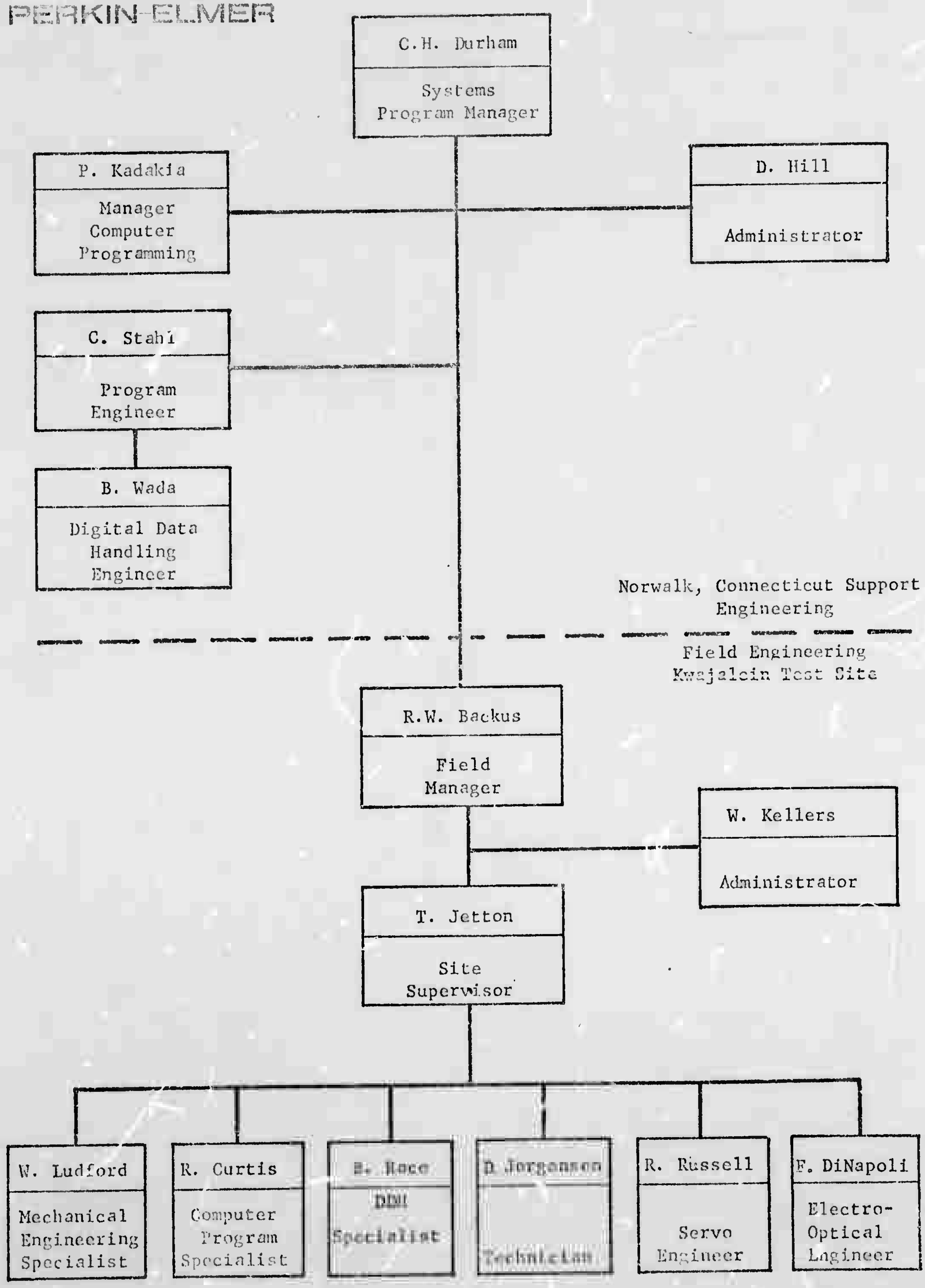


Figure 2-3. Organizational Chart - Project GLOW

In general, equipment damages from transportation were relatively minor.

The instrument van outer skin (one bottom section) was severely damaged. Fortunately, the inner RFI skin or under the floor cabling was not damaged. Repairs were effected locally by the Aircraft Maintenance Section.

The crate containing the computer teletype unit was damaged and the unit was inoperative. Repair of the teletype unit was made by Kentron technicians at Kwajalein.

Surface corrosion damage to the metal clad screen room panels was extensive. Cleaning was effected on site.

2.5 INSTALLATION

The Station log of Appendix A and the Chronological Summary of paragraph 2.6 detail installation events.

Salient installation highlights include:

1. Preparation of GLOW Facility. Sealing of concrete floors for moisture and dust control. Leveling to 1/8" the floor area under the screen room. Construction, from shipping crates, of shop and storage areas.
2. Emplacement of the roof mounted equipment, i.e., the NIKE-AJAX pedestal (figure 2-4), the 16-foot diameter Astrodome unit (figure 2-5), the calibration railbed console and collimator, and the 24-inch cine-spectrograph alignment mirror.
3. Erection of the shielded screen room.
4. Installation of ceiling hung cable raceways.
5. Installation of cabling and hydraulic lines for the Astrodome and all system interconnections.
6. The design of the auxiliary frequency converter building utilizing a surplus missile casing.
7. The installation of the B-50 sighting station.

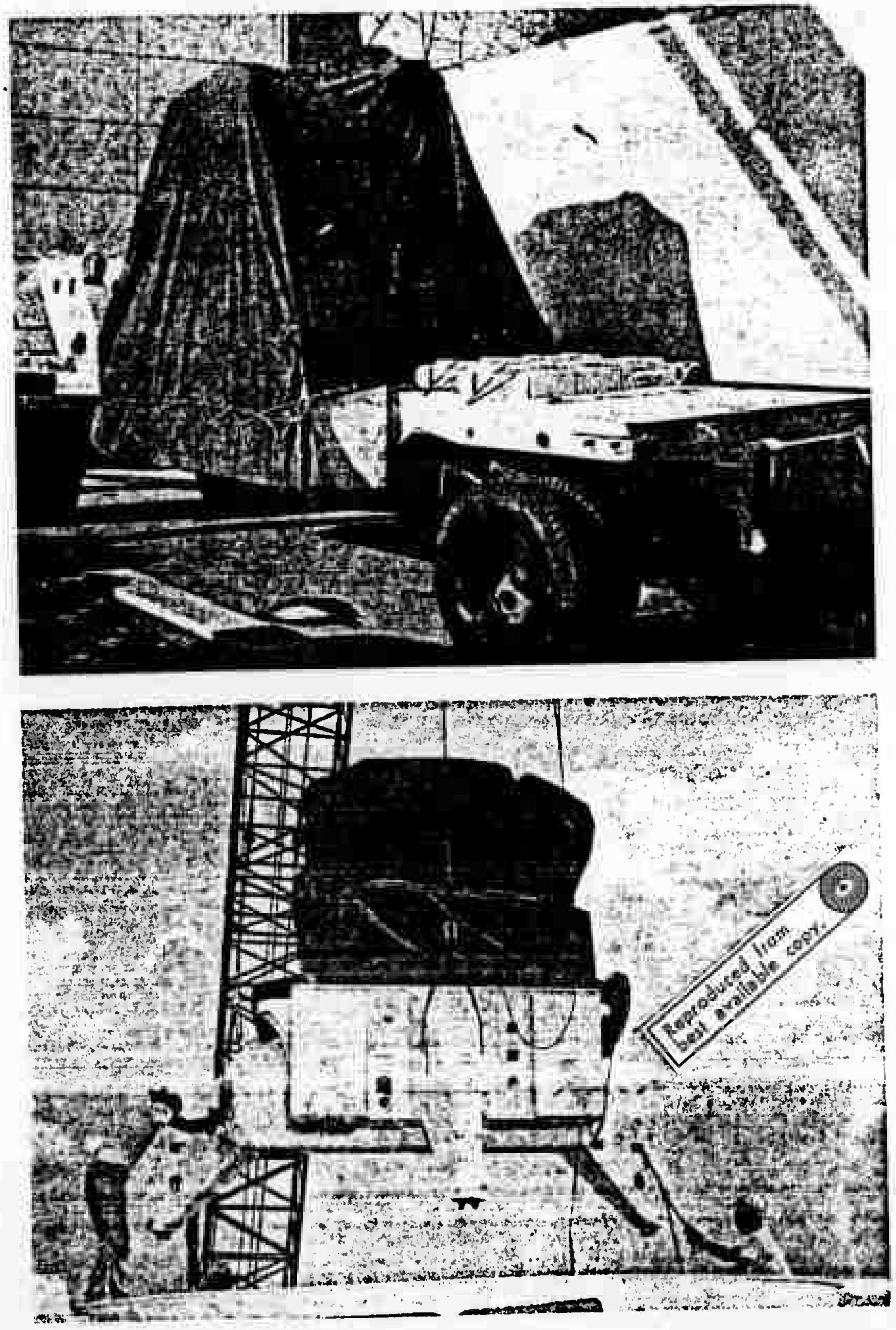


Figure 2-4. Installation of NIKE-AJAX Pedestal
(Sheet 1 of 2)

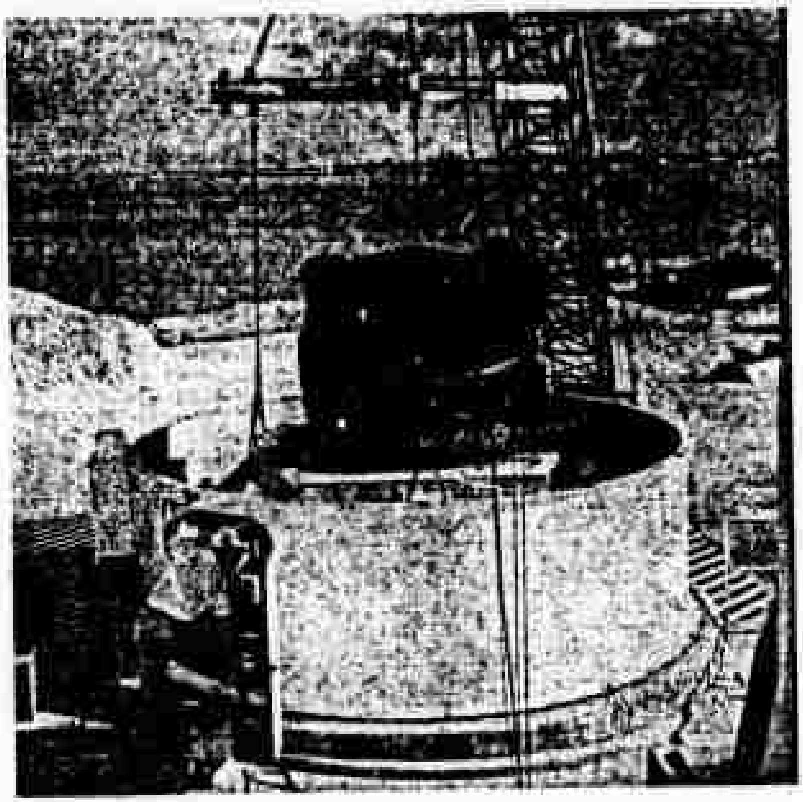
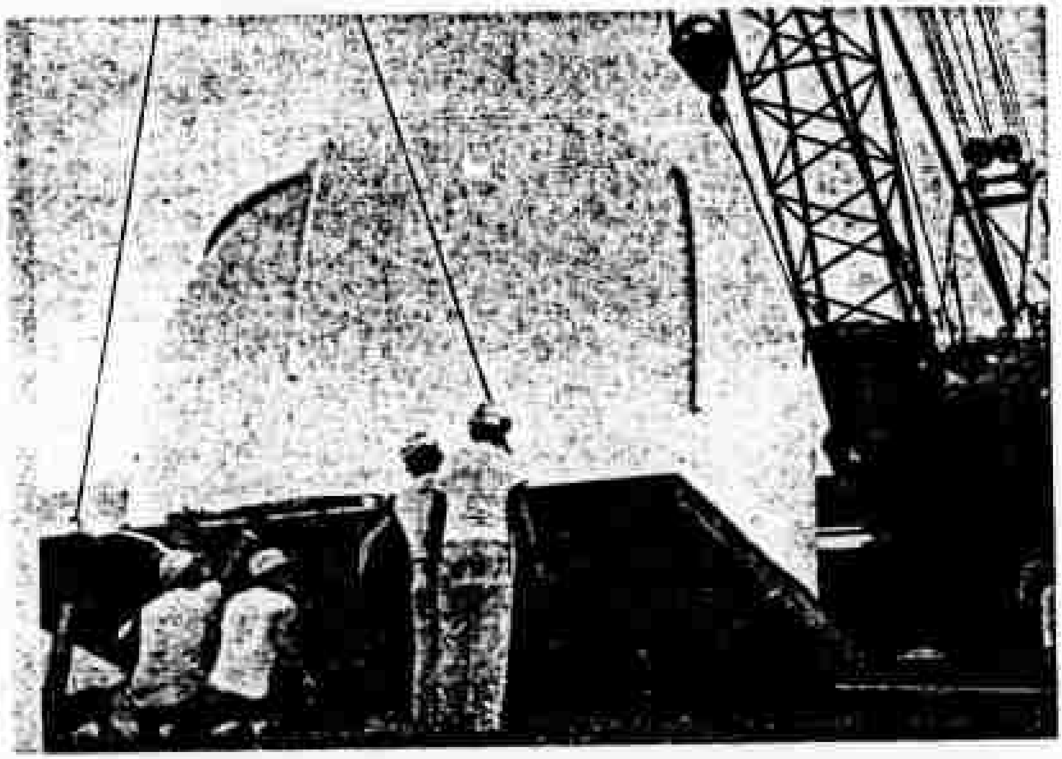


Figure 2-4. Installation of NIKE-AJAX Pedestal (Sheet 2 of 2)



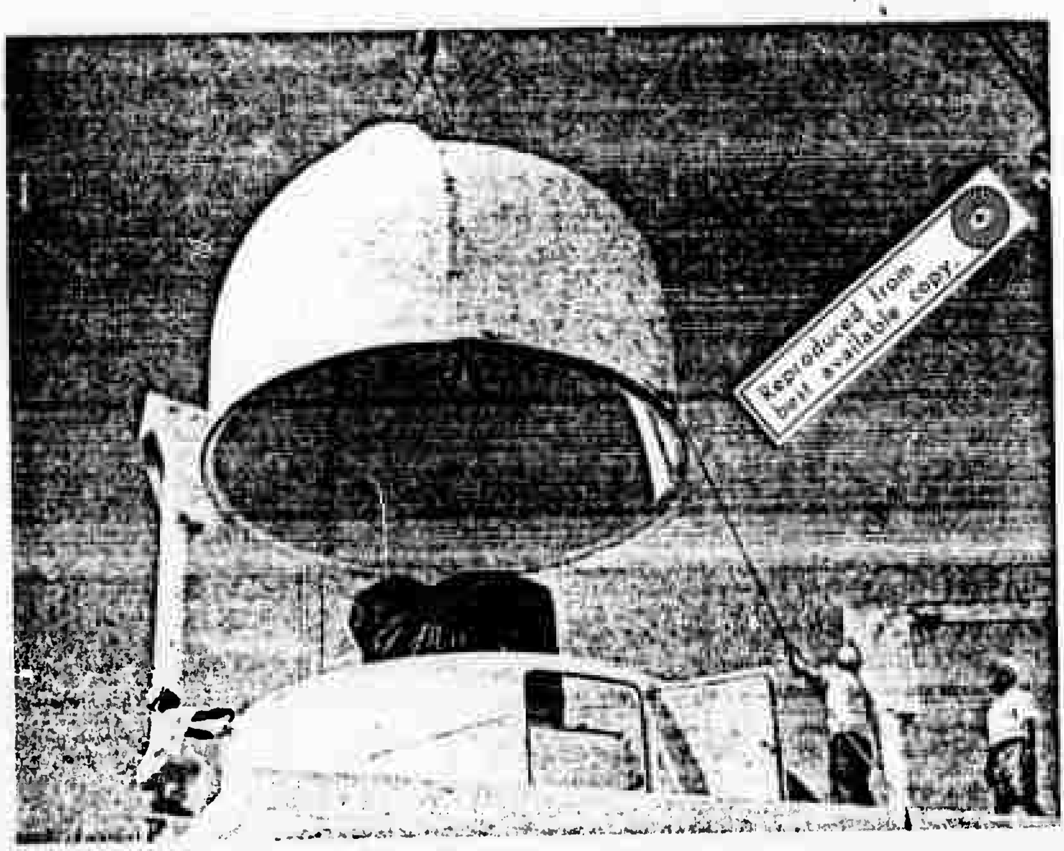


Figure 2-5. Installation of Astrodome Unit
(Sheet 1 of 2)

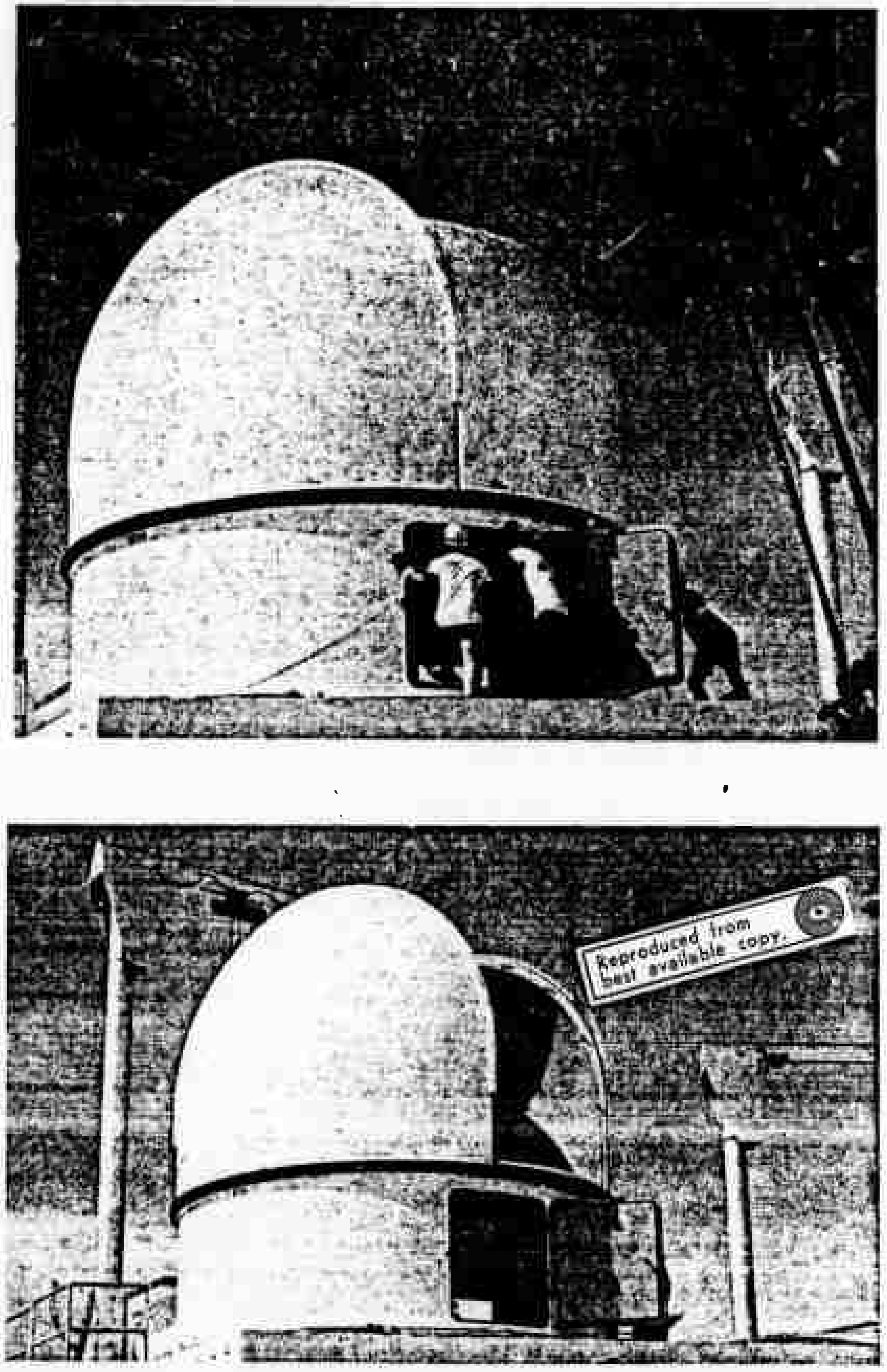


Figure 2-5. Installation of Astrodome Unit
(Sheet 2 of 2)

2.6 CHRONOLOGICAL SUMMARY (See Table 2-2.)

TABLE 2-2. CHRONOLOGICAL SUMMARY (Sheet 1 of 2)

Period	Events
10 Oct. - 13 Oct. '66	Arrival of field crew on Kwajalein Test Site.
14 Oct. - 31 Oct. '66	Establish liaison with KTS support agencies. Began Site preparation. Accept partial Group I shipment (22 Oct.; Utility Van and tools not included). Began erection of screen room. Installed Astrodome hydraulic power unit.
1 Nov. - 30 Nov. '66	Group II shipment and Utility Van arrived (9 Nov.). Temporary installation of frequency converter. Completed screen room and power wiring. Emplaced pedestal, Astrodome, and calibration equipment. Computer interface at Norwalk completed, equipment shipped to KTS. Began installation of ceiling hung cable ways.
1 Dec. - 9 Dec. '66	PECO Project Manager, C.H. Durham, arrived for project review with AMICOM personnel . Plans drawn by PECO for auxiliary housing of frequency converter; utilizing surplus missile casing.
10 Dec. - 31 Dec. '66	Group IV equipment arrived (10 Dec., computer main frame and radiometer DEWAR misplaced in transit). Installation begun on computer facility; completed cable ways and external cabling.

TABLE 2-2. CHRONOLOGICAL SUMMARY (Sheet 2 of 2)

Period	Events
1 Jan. '67 - 17 Jan. '67	Received and emplaced Instrument Van and computer main frame. Installed balance of equipment.
18 Jan. - 31 Jan. '67	Power applied to complete system. Began system checkout.
1 Feb. - 28 Feb. '67	Continued system checkout and routine maintenance. Started Site survey for coordinate information. Continued Site preparation tasks (painting, construction of benches, storage of materials).
1 Mar. - 26 Mar. '67	Frequency converter installed in auxiliary building. System evaluation tests continued. Computer programming started. Began preparation for interfacing of KTS communications and COBI net.
27 Mar. - 7 Apr. '67	AMICOM representative and General Electric personnel arrived to witness system performance. Transfer of system and inventory. Departure of PECO field crew.

2.7 COMMENTS ON CLIMATIC CONDITIONS

Since Perkin-Elmer's major efforts were directed, by contract, to installation and encompassed a period of only 5-1/2 months, statistical data concerning operations and equipment maintenance (which differ from the WSMR facility) is lacking.

However, the climatology typical of an equatorial Pacific Atoll may lead to difficulties in particular areas of equipment maintenance and operation.

The intent of this section is to present, as a commentary, these possible problem areas.

2.7.1 Climatological Data Summary

"Kwajalein is located less than 700 miles north of the equator" and " has a tropical marine climate characterized by (1) relatively high annual rainfall and (2) warm to hot, humid weather throughout the year."

"The principal rainfall season extends from mid-May to mid-December. Light, easterly winds, almost constant cloudiness and frequent moderate to heavy showers prevail during the wet season." (See figure 2-6.)

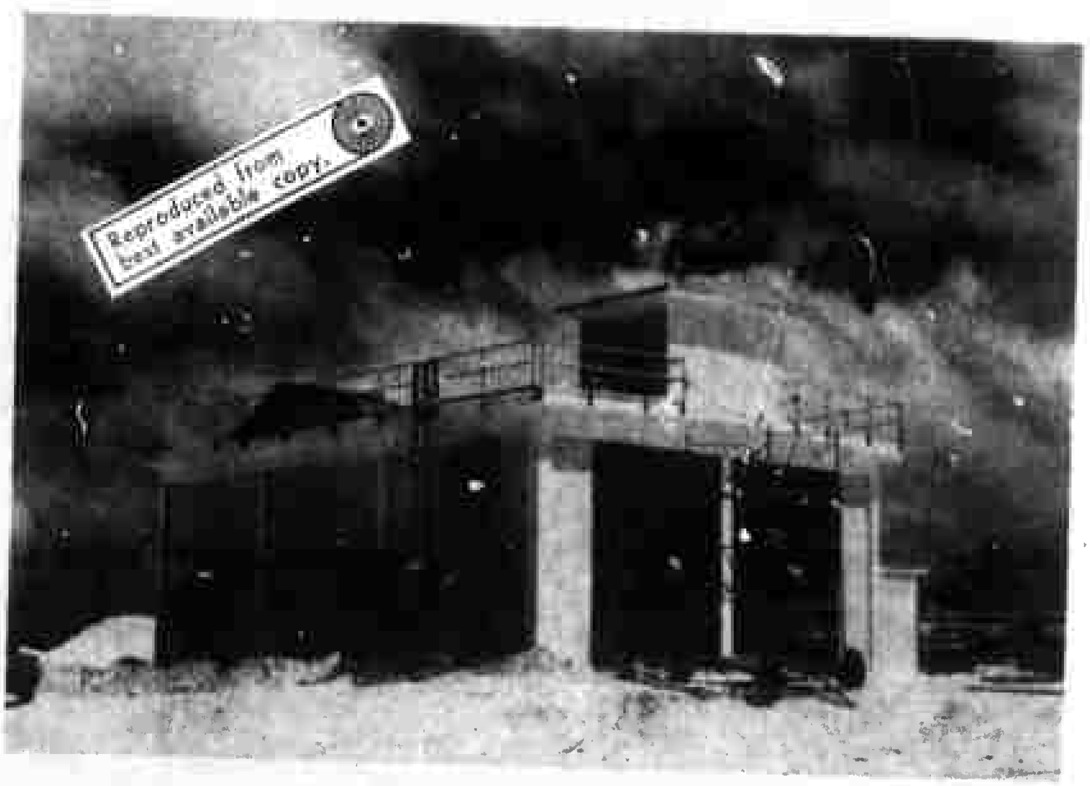


Figure 2-6. GLOW System Shown During Inclement Weather (Prior to Completion)

"The dry season includes the period mid-December to mid-May, and is characterized not so much by lack of showers as by light showers of short duration. In this season, trade winds are persistent, blowing from the northeast 15-20 knots almost continuously."

"The relative humidity is uniformly high throughout the year" and "the combination of high humidity and proximity of the salt water ocean present a corrosion problem."

During the 1966 period, statistics collated at the Kwajalein airport station are summarized in Table 2-3.

TABLE 2-3. CLIMATOLOGICAL DATA

Precipitation - 116.19 inches	
Temperature -	
Daily Maximum (average)	86.8°F
Daily Minimum (average)	76.8°F
Relative Humidity - Average (yearly)	
Midnight (LST)	83%
Noon (LST)	76%

The above climatological data and excerpts are reported in U.S. Department of Commerce document, "Local Climatological Data, Kwajalein, Marshall Islands, Pacific, 1966", which is reproduced for informational value in Appendix B.

2.7.2 Discussion of Probable Problem Areas

The majority of equipment is housed within the air-conditioned facility and is not often subjected to either (1) prolonged exposure periods in island climate or (2) frequent open periods where temperature gradients exist between the air-conditioned and natural environment.

Attention is directed to the following areas:

1. Deterioration of metal components and insulating or fabricated plastics by corrosion, salt deposits, and bacterial or fungi attack.

   Particular items include the frequency converter, pedestal mounted equipment in the Astrodome, and the calibration equipment. (See figures 2-7 through 2-9.)

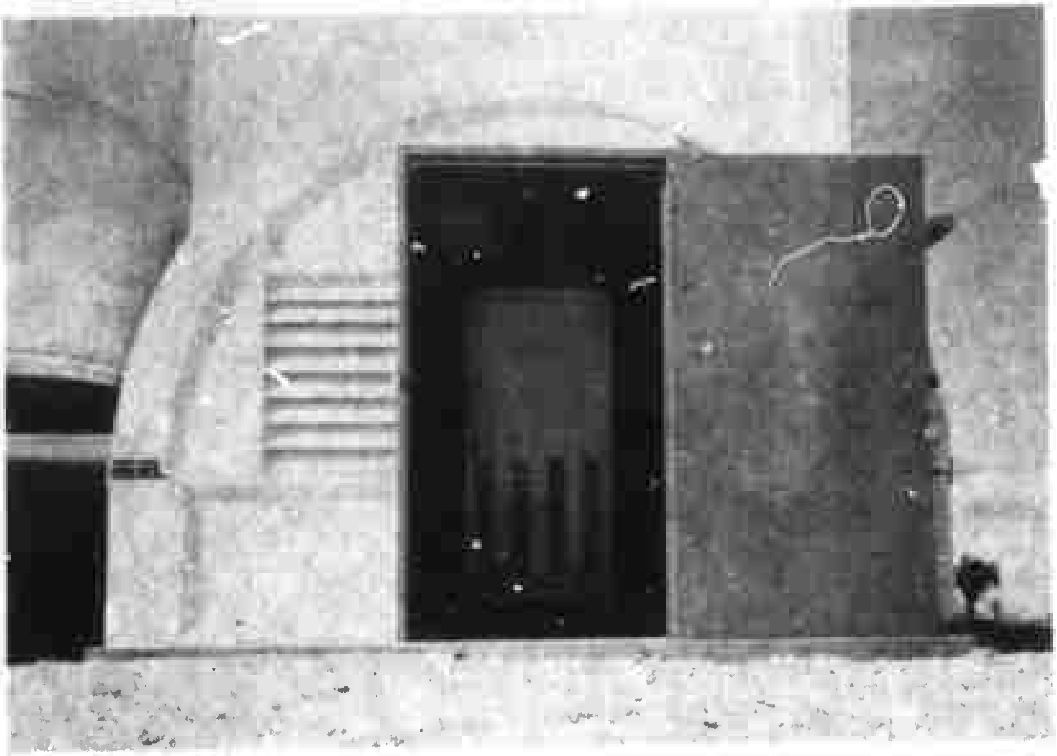


Figure 2-7. Frequency Converter in Utility Building

Figure 2-8. Pedestal Mounted Equipment in Astrodome Unit

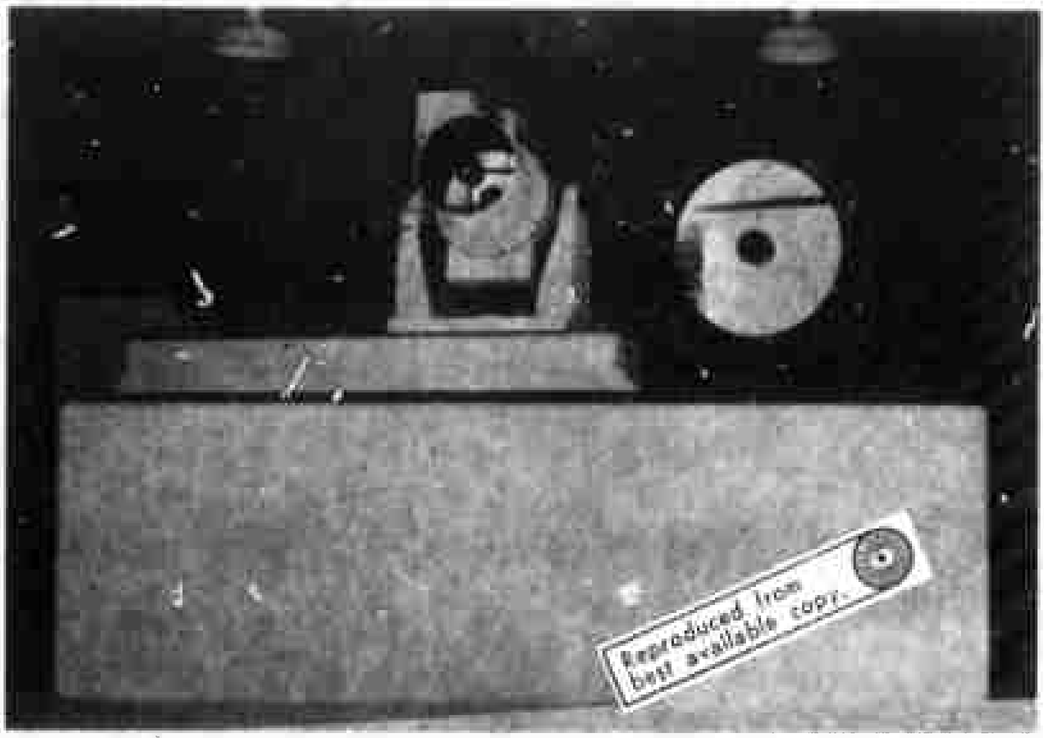


Figure 2-9. Calibration Equipment - Collimator and 24-Inch Mirror

2. Deterioration of coated optical surfaces by gradual salt deposition and moisture condensation with the resulting frequent requirement for optical cleaning.

3. Loss of cooling (InSb detector) or detector damage by excessive moisture in the cryogenics system (Radiometers).

4. Calibration of radiometers or similar optical instrumentation. Repeatability of calibration data is dependent upon similar or known control parameters. Unobserved condensation on optical surfaces, or large excursions in atmospheric parameters, will result in non-reproducible data for what otherwise are similar testing parameters (field stops, temperatures, etc.).

2.7.3 Summary and Recommendations

Briefly summarizing, the climatological conditions present at Kwajalein can lead to equipment failure and operational difficulties.

It is recommended that maintenance and inspection schedules be prepared and performed, regularly, particularly for equipment in the Astrodome, calibration building, and the frequency converter.

Further, temperature and humidity control of the facility air-conditioning system should be utilized fully when exposing equipment to the environment in the calibration building or Astrodome. Dehumidifiers and/or strip heaters on critical components may prove beneficial if used on a continual basis.

The use of dry and heated nitrogen purging of the radiometer cryogenics system and optical components is essential to prevent deterioration of optics and the proper cooling of the InSb detectors.

SECTION III

SYSTEM PERFORMANCE

3.1 INTRODUCTION

The inspection of the GLOW facility and the demonstration of System performance were accomplished during the week ending Friday, 31 March, 1967.

Activities were focused on four (4) areas:

1. Inspection of physical facilities.
2. Demonstration of the modified NIKE-AJAX tracking system.
3. Demonstration of the GLOW computer facility.
4. Demonstration of system peripheral components.

3.2 SUMMARY

The contractual requirements for the installation of GLOW System II, as described in Section I, were successfully concluded with the verification of operational performance of System components, including the necessary Range interface and the transfer of System inventory.

3.3 APPLICABLE DOCUMENTS

The following report details the GLOW System equipment requirements pertinent to System performance:

> Engineering Report No. 8693, "Final Acceptance Test Procedure for the GLOW System at Kwajalein", Perkin-Elmer Corporation, dated 16 March 1967.

In addition, the documents listed in the bibliography of this report describe the technical and physical description of System components necessary for their operation.

3.4 REPORT CLARIFICATION

In order to clearly present the major results achieved during testing, and to preserve report brevity, the peripheral electronic functions are omitted from this report but were operational.

As an example, the vidicon television system was verified as operational. The necessary power supply voltages, ON-OFF switches, focusing, monitor linearity, etc., were operational but are not detailed.

Exceptions will be individually noted within the applicable section where the major subsystem is reported.

3.5 FACILITY ACCEPTANCE - GENERAL

While no specific requirements were generated for facility acceptance, the installation of equipment, test areas and work material storage, office facilities, power and cabling interconnections, and exterior emplacement of supporting vans and storage areas were executed with consideration to the functional, safety, and esthetic requirements of the GLOW System.

3.5.1 Performance Verification - Subsystems

The following subsystems were verified as operational without exception:

1. Frequency Converter - 60 to 400 cycles.
2. Vidicon television system.
3. Calibration collimator and collimator console.
4. 35mm boresight camera with framing and coding film format.
5. Astrodome with its servo system.

3.6 COMPUTER AND DIGITAL DATA HANDLING (DDH) SYSTEMS - GENERAL

The operation of the SDS 930 general purpose computer and its associated peripheral hardware (such as the teletype writer and magnetic tape recorder) and DDH system was demonstrated in three modes.

1. Static operation of the computer system.
2. Utilization of the computer and DDH systems to generate command functions for the servo tracking system evaluation.
3. Static operation of the DDH system.

3.6.1 Computer Operation

The computer operation was checked to the standard specification test as published by SDS. Total performance was demonstrated by utilizing diagnostic programs which simulate every mode and instructive command within the computer system.

The following programs were loaded and executed:

1. Program #304001, 930 Examiner Memory Diagnostic.
2. Program #304002, 930 Examiner Diagnostic Instruction.
3. Program #304003, 930 Examiner.
4. Program #024001, Paper Tape Photo Reader Test Program.
5. Program #544001, Multi Mag Tape Exerciser.
6. No applicable number, Teletype Echo Test.

During the last two days of the installation acceptance program, the write section of the mag tape became inoperative. Repairs were not effected since spare parts were not funded for this unit.

3.6.2 Digital Data Handling (DDH) System

The DDH system was demonstrated for general compliance with Section 4.5 of NR-490 by feeding in the appropriate tracking data signals and printing out the resultant.

3.6.3 Computer and DDH Tracking Verification

This test was designed to verify the characteristics of the pedestal servo system tracking capability to an actual prerecorded TRADEX generated trajectory.

In addition, this test verified the dynamic characteristics of the computer and the DDH in processing radar command inputs in a simulated tracking exercise.

The results of the servo evaluation are detailed in paragraph 3.7.

3.7 SERVO SYSTEM EVALUATION

3.7.1 General

The servo evaluation utilized the computer facility to develop command functions required in the analysis of servo performance. Generated ramps, steps, and parabolic functions were used in the velocity loop evaluation. In addition, a prerecorded TRADEX (COBI) message generated tracking commands to demonstrate servo performance from a simulated mission radar input.

3.7.2 Servo System Evaluation - Objective

The analysis of GLOW II servo system performance was accomplished in three steps.

1. Evaluation of the servo's velocity loop performance before shipment from the factory to Kwajalein.

2. Evaluation of the servo system's velocity loop performance after shipment of the system to Kwajalein.

3. The optimization of the entire servo system in its various tracking modes, with the present instrumentation load on the pedestal.

3.7.2.1 Velocity Loop Performance. To a great extent, the ability of any tracking system to function correctly is determined by the system's velocity loop performance. The evaluation of its characteristics provides a good means of determining the probable performance of the closed loop tracking capability of the system. Figure 3-1 presents a block diagram of GLOW II's velocity loop servo system. GLOW II utilizes a modified NIKE-AJAX tracking mount. In place of the pedestal's former pay load, a radar dish, a rigid instrumentation platform has been substituted. NIKE HERCULES drive motors have been substituted for NIKE-AJAX drive motors in the servo system. With these exceptions, the remainder of the mount's velocity loop servo system remains unchanged.

To maintain controlled conditions, the initial tests on the system's velocity loop at the factory and at Kwajalein were both performed with the same simulated load on the mount's instrumentation platform. This load was such that the inertia about the azimuth and elevation axes of the mount was 1-1/2 times that which would be present with the GLOW II instrumentation package mounted on the pedestal's instrumentation platform.

For any given tracking system, velocity loop performance is determined by the reflected inertia in both axes: to the mount's torque motors and to the amount of the tachometer feedback selected. This assumes that all loop components are operating to their peak capability and that the system is taken as is with no substitution of higher performance torque motors. The proportion of tachometer feedback used will determine the maximum tracking velocity, acceleration, and the -3 db frequency response point of the velocity loop. This assumes a fixed instrumentation load on the mount. Increasing the inertia or load about either axis will lower that axis's maximum tracking acceleration and velocity loop bandwidth. The maximum tracking velocity will not be affected by an increase in the load providing that bearing friction is not increased substantially. This, in general, does not occur unless the load is increased by a large amount.

Velocity loop performance is evaluated by measurement of the loop's 3 db frequency response point, maximum loop tracking velocity, and acceleration.

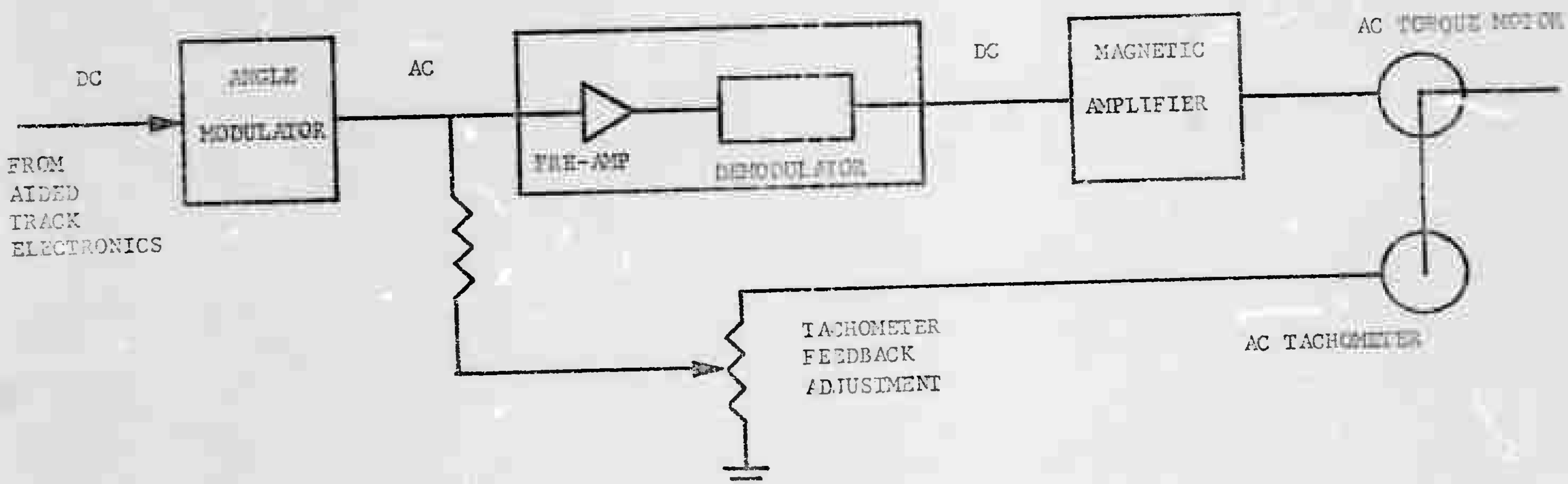


Figure 3-1. Nike-Ajax Velocity Loop Azimuth and Elevation Axis

Table 3-1 presents the figures obtained from the measurement of these parameters, both at the factory and in the field.

With reference to Table 3-1, it will be noted that the velocity loop's servo system suffered a slight degradation in performance after system shipment to the field. However, after adjustment and replacement of several components in the velocity loop, its performance was upgraded to a point where the performance figures obtained were either equal to or in excess of those obtained at the factory.

TABLE 3-1. AZIMUTH AND ELEVATION VELOCITY LOOP PERFORMANCE

Axis of Rotation	Maximum Loop Tracking Velocity °/sec		Maximum Loop Tracking Accel. °/sec^2		-3db Freq. Response Pt. CPS	
	Factory	Kwajalein	Factory	Kwajalein	Factory	Kwajalein
Azimuth	42.77	32.05	49.06	47.56	1.15	0.98
Elevation	40.42	39.01	50.55	46.57	1.19	0.88

NOTE:

In all cases, the above figures represent the average figures obtained from a minimum of three (3) data runs.

3.7.3 Initial Consideration for Kwajalein Operation

To prepare the pedestal for optimization of Kwajalein tracking requirements, the following actions were accomplished.

1. Determination of the maximum tracking velocities and accelerations.
2. Setting the velocity loop tach feedback to meet these requirements with the instrumentation load installed on the mount.
3. Determination of the proper servo compensation network to provide stable closed loop performance with minimum tracking error.
4. The final setting of loop gains to provide optimum performance.

The above steps were taken with each of the System's three modes of position control: radar slaved computer control, B-50 synchro slaved mode, and the manual stiff stick control.

The analysis of the tracking requirements on Kwajalein indicated that the maximum tracking velocity to be encountered would be around 10 deg/sec with maximum tracking accelerations to be no greater than 5 deg/sec^2. In view of these requirements, the azimuth and elevation velocity loop tachometer feedback was adjusted to provide velocity loop performance as indicated in Table 3-2 with the GLOW II's present instrumentation load.

TABLE 3-2. OPTIMUM AZIMUTH AND ELEVATION VELOCITY LOOP PERFORMANCE

Maximum Tracking Velocity deg/sec		Acceleration deg/sec^2		Velocity Loop Bandwidth CPS	
Azimuth	Elevation	Azimuth	Elevation	Azimuth	Elevation
30	32	45	50	2.5	3.0

NOTE:

1. The above data is the average of the parameters obtained from five separate data runs.
2. All parameters obtained with input voltages to velocity loop below saturation level of the loop. In the saturation region, both azimuth and elevation axes are capable of maximum tracking velocities of 35 deg/sec and maximum tracking accelerations of 58 deg/sec^2. However, in both loops bandwidth is reduced when the velocity loop is saturated.
3. The velocity loop bandwidth shown represents an average value. Below loop saturation, small changes in loop bandwidth were experienced by varying input voltage peak amplitude.

Table 3-2 indicates that the mount is more than capable of meeting the tracking velocity and acceleration requirements on Kwajalein.

The next step in preparing the servo system for operation was to determine the maximum allowable tracking error and servo dynamic lag error. From this analysis, the amount of forward loop servo gain can be determined. From this figure, the proper servo compensator for each of GLOW II's position control loops was determined.

The minimum field of view on any of the present instruments on GLOW II is 4 milliradians. This represents the total field of view for each of the two dual channel radiometers. Therefore, the total tracking error must never exceed 2.0 milliradians, or 1/2 the total field of view of the radiometers. To insure that GLOW II would perform its mission, it was assumed that the total or peak tracking error in either axis could not exceed 1 milliradian. In addition, it is assumed that the tracking rates in either axis will be substantially higher than set forth previously.. Table 3-3 sets forth these assumptions.

TABLE 3-3. ASSUMED VS. PROBABLE TRACKING RATES AT GLOW II SITE KWAJALEIN

	Maximum Tracking Rates				Max Tracking Error Milliradian	
	Azimuth		Elevation			
	Max Accel °/sec^2	Max V °/sec	Max Accel °/sec^2	Max V °/sec	AZ	EL
Probable	5	10	5	10	2.0	2.0
Assumed	10	30	10	30	1.0	1.0

GLOW II utilizes a type II servo system in each axis; therefore, no velocity tracking errors should occur. In actual practice, there will be a very small error which we shall consider negligible. Therefore, it may be stated that:

$$E = \frac{\alpha\ (t)}{K_A} \qquad (1)$$

where

α (t) = Target acceleration (deg/sec^2)

K_A = Acceleration constant or forward loop servo gain (1/sec^2)

E = Servo lag or tracking error (deg)

GLOW II must have a forward loop servo gain in each axis of:

$$K_A = \frac{\alpha\ (t)\ \max}{E\ \max} = \frac{10\ \mathrm{deg/sec}^2}{0.0573\ \mathrm{deg}} = 175\ 1/\mathrm{sec}^2$$

This gain must be achieved for both the radar slaved computer controlled position loop and the synchro slaved B-50 position controlled loop.

The above analysis is based on the assumption that the only position error observed there, during a dynamic tracking event, will be servo lag error. If the system is receiving its positioning commands via the radar link to the range from Tradex, it must be assumed, to establish a starting point, that the radar information is precise. In other words, it is assumed that the Tradex radar is tracking the incoming target with 0 position error. In addition, it should be noted that any noise or dropout in the radar tracking data received at the GLOW site can add further to the actual tracking error. This, of course, applies only to the system's performance when tracking in the computer controlled radar mode. Actual tracking error is defined as the total position error, at any time, between the mount's optical boresight axis and the target being tracked.

The total system error is the sum of the above plus all errors occurring during any dynamic tracking event. The actual tracking error can be broken down into components. The major ones are as follows:

1. Servo system lag or tracking errors.
2. Bearing wobble.
3. Mechanical resonance of pedestal.
4. Servo system electrical or electronic noise.
5. Misalignment of instruments, boresight errors.
6. Gear backlash.

The total position error due to all causes, except item 1, is estimated to be 0.2 milliradian max.

By far, the larger or most predominant system error will be due to the servo system lag error. From this point on, it will be assumed that the total or actual tracking error is equal to the servo lag error. Experience with GLOW I and II and other similar systems has shown that, for the degree of tracking accuracy required, 2.0 milliradians, this is not an invalid assumption.

3.7.4 Evaluation of Servo Tracking Capabilities

3.7.4.1 Radar Slaved Computer Controlled Loop. The radar mode of track utilizes a processed and updated Tradex (COBI) message to provide the azimuth and elevation pointing information to correctly position GLOW II's instrumentation package. This information is originally generated by the Tradex radar on ROI NUMIR. It is then corrected to the D.R. radar on Kwajalein. The message is received at the GLOW II site in COBI form which provides the desired pointing information in Cartesian, XYZ, Coordinate form.

GLOW receives a new data point, or target position, at the rate of ten per second. Upon arrival at the GLOW site, the message passes through an I/O

junction box where it is converted from serial form to parallel form. Next, the message receives a time tag, which references it to computer time. At this time, a subroutine "Kadkia" is called and applied within the computer which updates the message in such a fashion that 40 actual data points are provided each second. This technique predicts additional data points to fill in between those times when the range is not sending GLOW a pointing message or data point. (Tradex data points are at 10 per sec; GLOW requirements are at 40 data points per sec.) The prediction is done on the basis of previous target data points which have been stored within the computer. After prediction, the message is converted from Cartesian coordinates to the standard azimuth and elevation angular pointing data necessary to correctly position the NIKE-AJAX tracking mount. The above traces the position information signal flow in the broadest sense only. It should be pointed out that, in addition to the above, various other operations are performed on the original message to correct it for the specific tracking situation on Kwajalein.

The computer next outputs the above target position message to the DDH. Here the azimuth and elevation command angles, or target position angle information, are compared with the actual mount position angle as developed in each axis by the 17 bit shaft angle encoders. The position angle is subtracted from the command angle. This difference, the actual tracking error, is next converted from digital to analog form and outputted from the DDH to the aided track electronics. All the above digital data is handled and processed in real time.

The aided track package provides the proper servo compensation and amplification of the analog error signal to drive the NIKE-AJAX velocity loop and, hence, the pedestal. Figure 3-2 presents a signal flow diagram for the digital information. Figure 3-3 presents a block diagram of GLOW II's entire computer controlled position loop.

Double lead single lag compensation was used to stabilize each of GLOW II's three position loops; the network used is illustrated in figure 3-3. The compensator break points, along with all pertinent data, are presented in Table 3-4 for the radar loop. Open position loop BODE plots are shown in figures 3-4 and 3-5 for the azimuth and elevation radar loops.

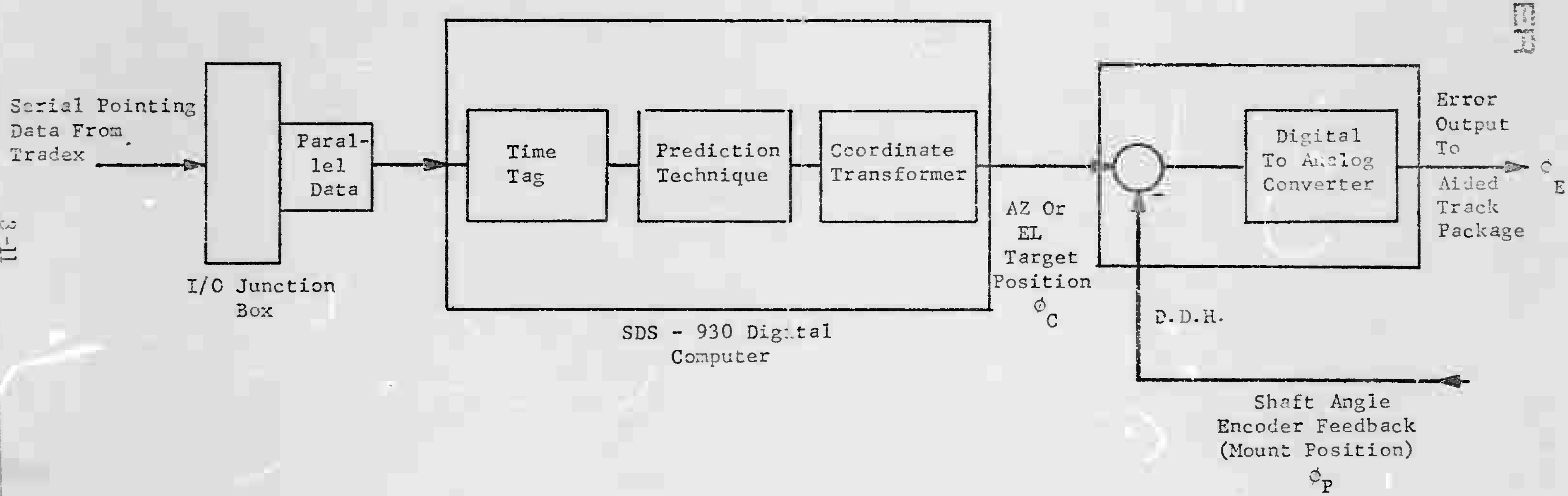


Figure 3-2. Digital Processing of Target Position

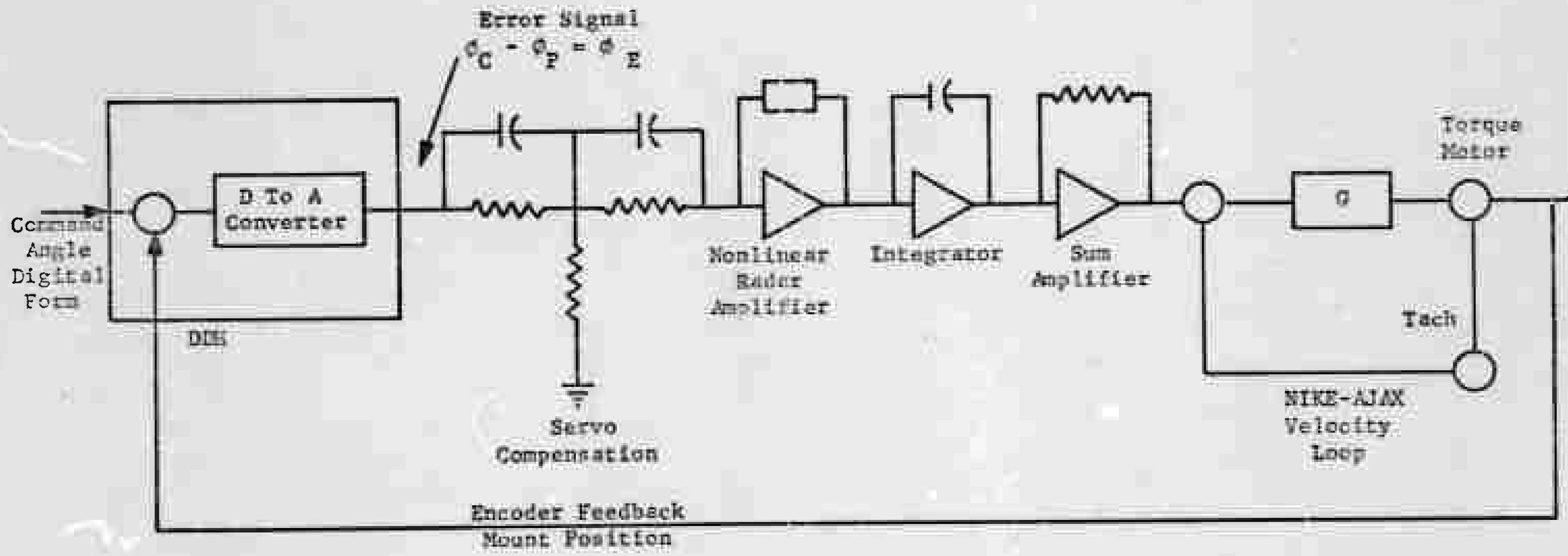


Figure 3-3. Block Diagram of GLOW II Computer Controlled Position Loop

TABLE 3-4. COMPENSATION FOR GLOW II RADAR LOOP

Axis	Compensator Breakpoints Radians/sec			Loop Bandwidth Radians/sec	Accel. Constant $1/sec^2$	Phase Margin (deg)
	ω_1(lead)	ω_4(lead)	ω_3(lag)			
Azimuth	9.7	25.6	∞	15.7	175	48.0
Elevation	8.5	21.3	∞	18.8	175	60.0

The single lag contributed by the compensator is more than one frequency decade above the ODB crossover frequency on the BODE plots shown in figures 3-4 and 3-5. It is considered to be at infinity in the calculation of the servo phase margin. The only other assumption made in the stability analysis of radar loop was that pedestal mechanical resonance was negligible. It occurs at about 18.0 cps in each axis. The resonance would appear as a highly damped second order quadratic on the BODE plots. Here, again, the point in question appears more than one decade in frequency above the ODB crossover point on the BODE plots and can be neglected in the loop stability analysis. The phase margin shown in Table 3-4 for each axis is more than adequate to provide stable servo operation. Tests run on the closed radar loop bore out the phase margin figures. No more than 1-1/2 overshoots were measured when the system was allowed to "lock on" to various static points in either axis.

3.7.4.2 Tracking Capability. To evaluate the servo tracking capability, three (3) trajectories were generated within the computer and outputted to the mount.

1. A parabolic (constant acceleration) trajectory commanding either a $10°/sec^2$ or $13.67°/sec^2$ tracking rate.
2. A ramp (constant velocity) function with a 10 degree/sec $\pm 0.2°$/sec tracking rate.
3. A Tradex nominal real time trajectory (#1105) as transmitted to Project GLOW.

All tests were run with the servo compensation shown in Table 3-4; the servo system was set up to provide the acceleration constant (175 $K_A = 1/sec^2$) calculated in paragraph 3.7.3.

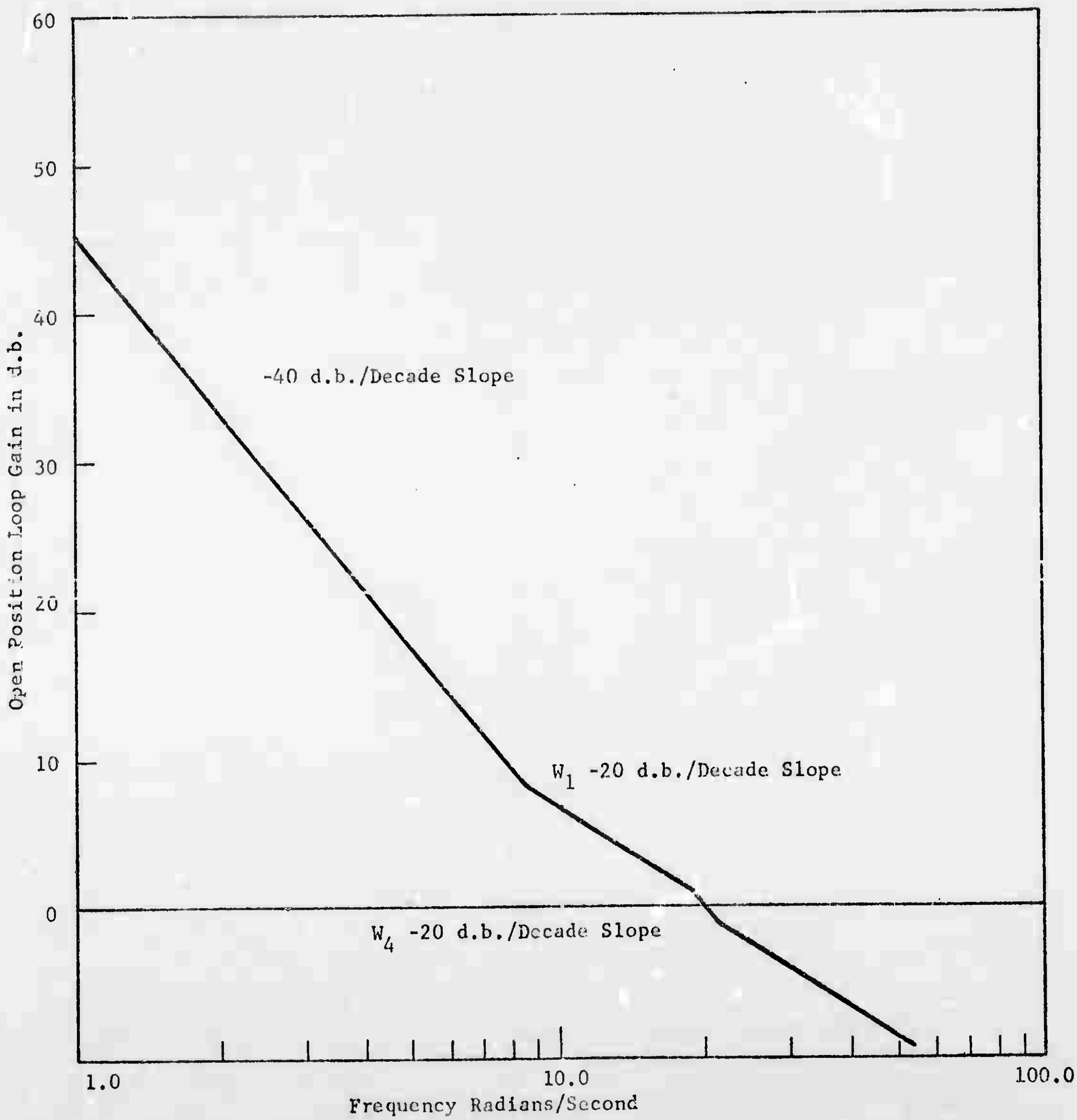


Figure 3-4. Open Loop Frequency Response Elevation Axis

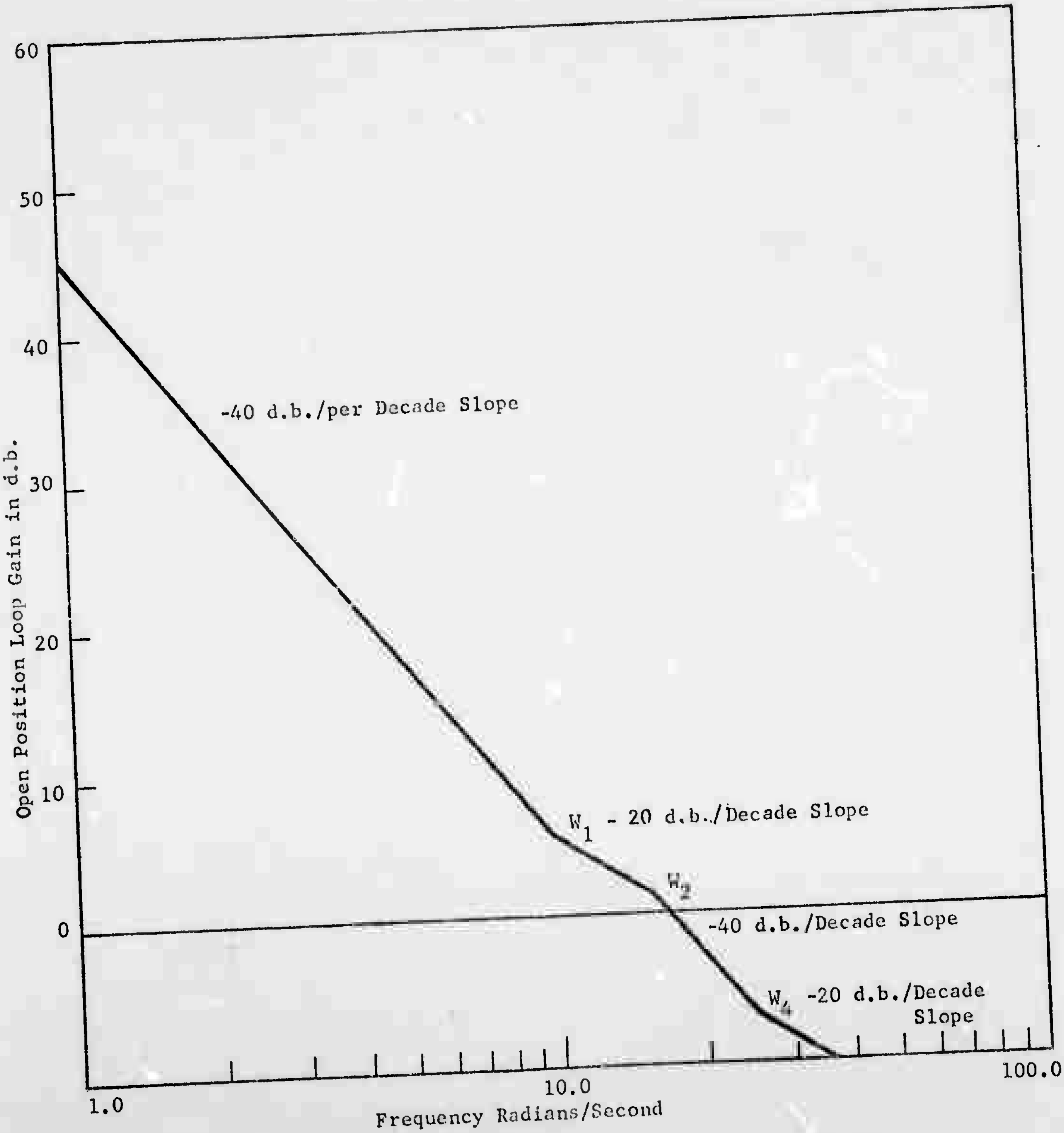


Figure 3-5. Open Loop Frequency Response Azimuth Axis

The command and position angles were digitally recorded; the computer's plotter was programmed to graph the tracking error (command minus position angle) in milliradians versus time in azimuth and elevation.

Table 3-5 summarizes the results of the tracking error evaluation. These figures are maximum peak error, offset from the theoretical zero by normal integrator drift.

These results show servo performance exceeding tracking requirements at the Kwajalein Test Site.

TABLE 3-5. SUMMARY OF TRACKING ERROR

Axis	10 deg/sec Ramp Traj Peak Tckg Error	$10\ deg/sec^2$ Parabolic Traj Peak Tckg Error	$13.67\ deg/sec^2$ Parabolic Traj Peak Tckg Error	Nominal Trajectory Tckg Error
Azimuth	0.87 mr	0.87 mr	1.57 mr	0.9 mr
Elevation	0.52 mr	0.87 mr	1.39 mr	0.3 mr

Note:

1. 10°/sec ramp trajectory will vary in rate from 9.8°/sec to 10.2 °/sec.
2. The indicated rates for the constant acceleration of the trajectory are average values. The average is determined by evaluating the equation used to generate trajectory over .1 second over the 5.5 second duration of the trajectory.

Figures 3-6 through 3-12 show the actual tracking error as plotted on the digital equipment for various input command functions.

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NOTE: Plot shown is derived from the comparison of the Tradex Nominal real time trajectory #1105 as transmitted to GLOW. The command angles are then generated by the computer from the real time program. The plot shows the difference of pedestal position and command angle during track.

Figure 3-?. Plot of Azimuth and Elevation Tracking Error During Kwajalein Acceptance Test

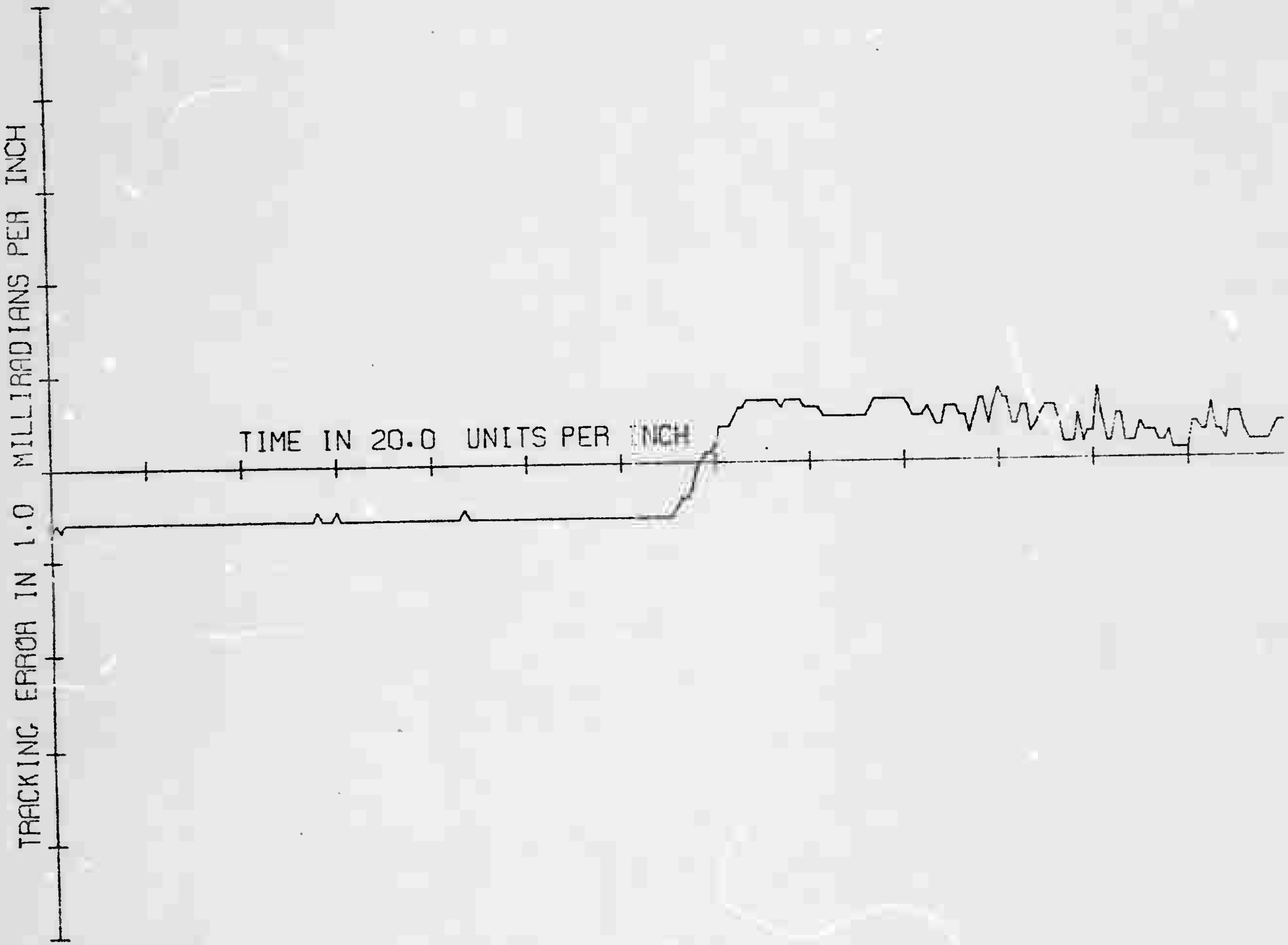


Figure 3-7. Tracking Error - Azimuth Accleration 10°/Sec^2 - Parabolic Trajectory

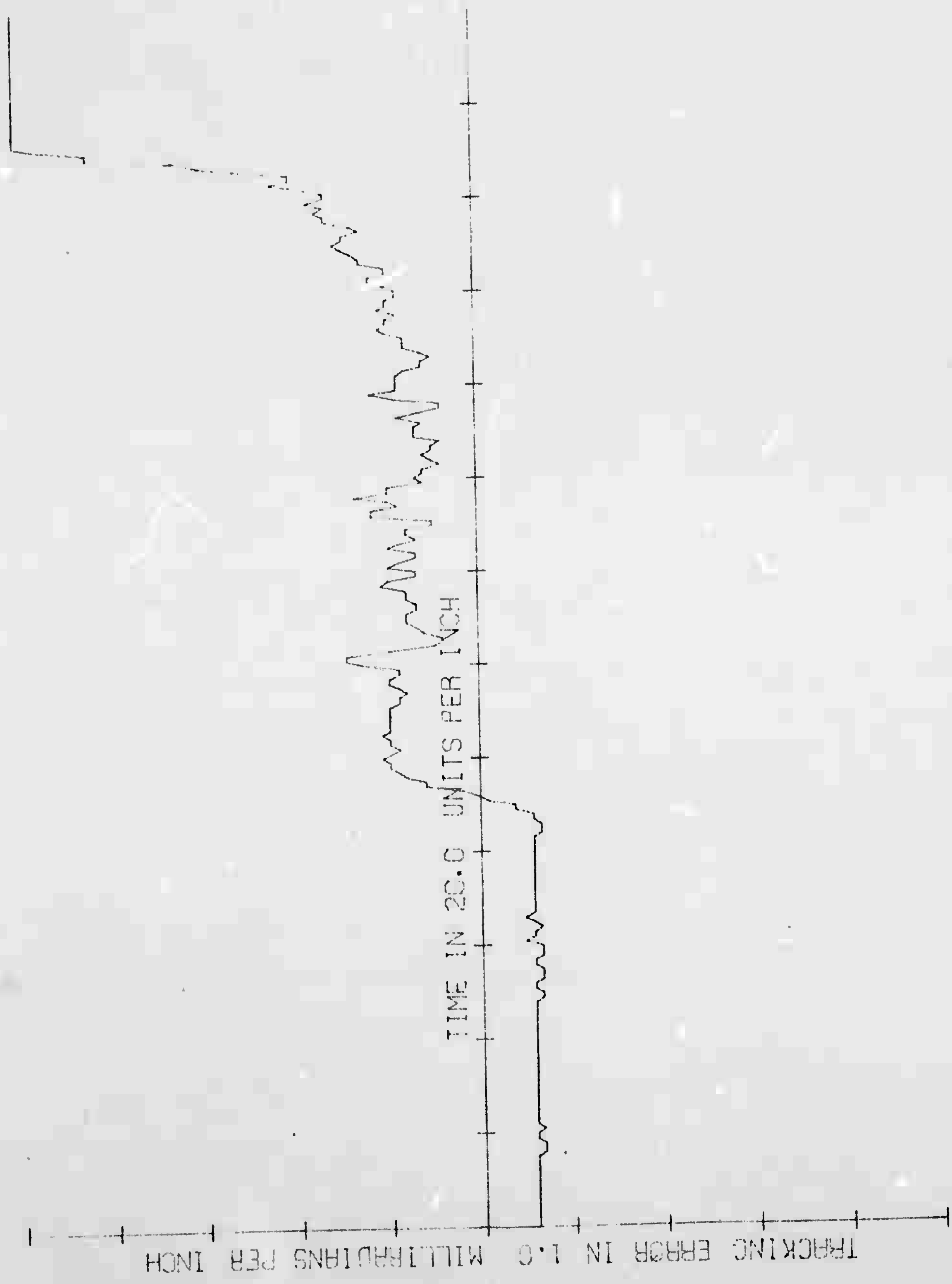


Figure 3-8. Tracking Error - Azimuth Acceleration 13.67°/Sec^2 - Parabolic Trajectory

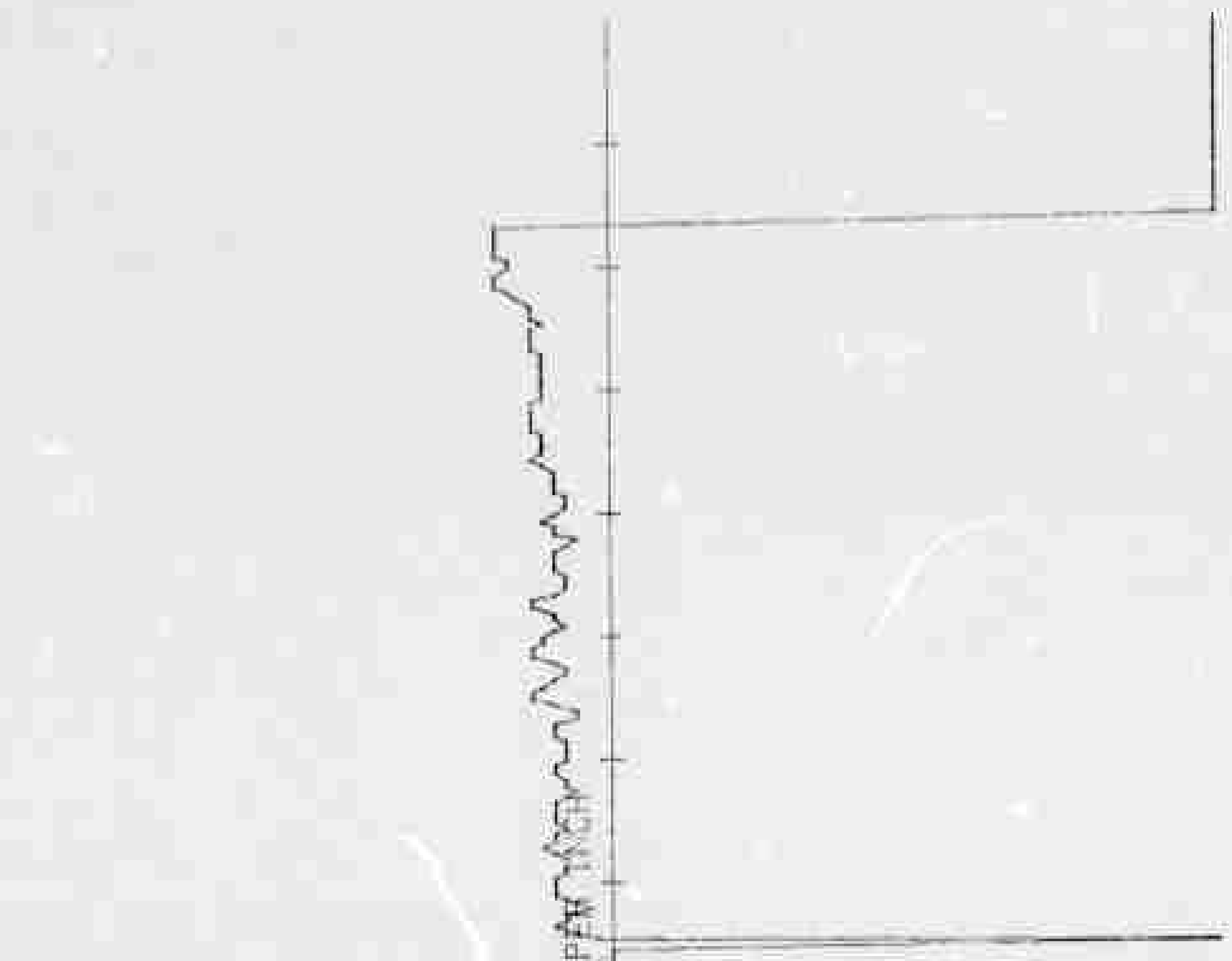


Figure 3-9. Tracking Error - Elevation Acceleration 10°/Sec^2 - Parabolic Trajectory

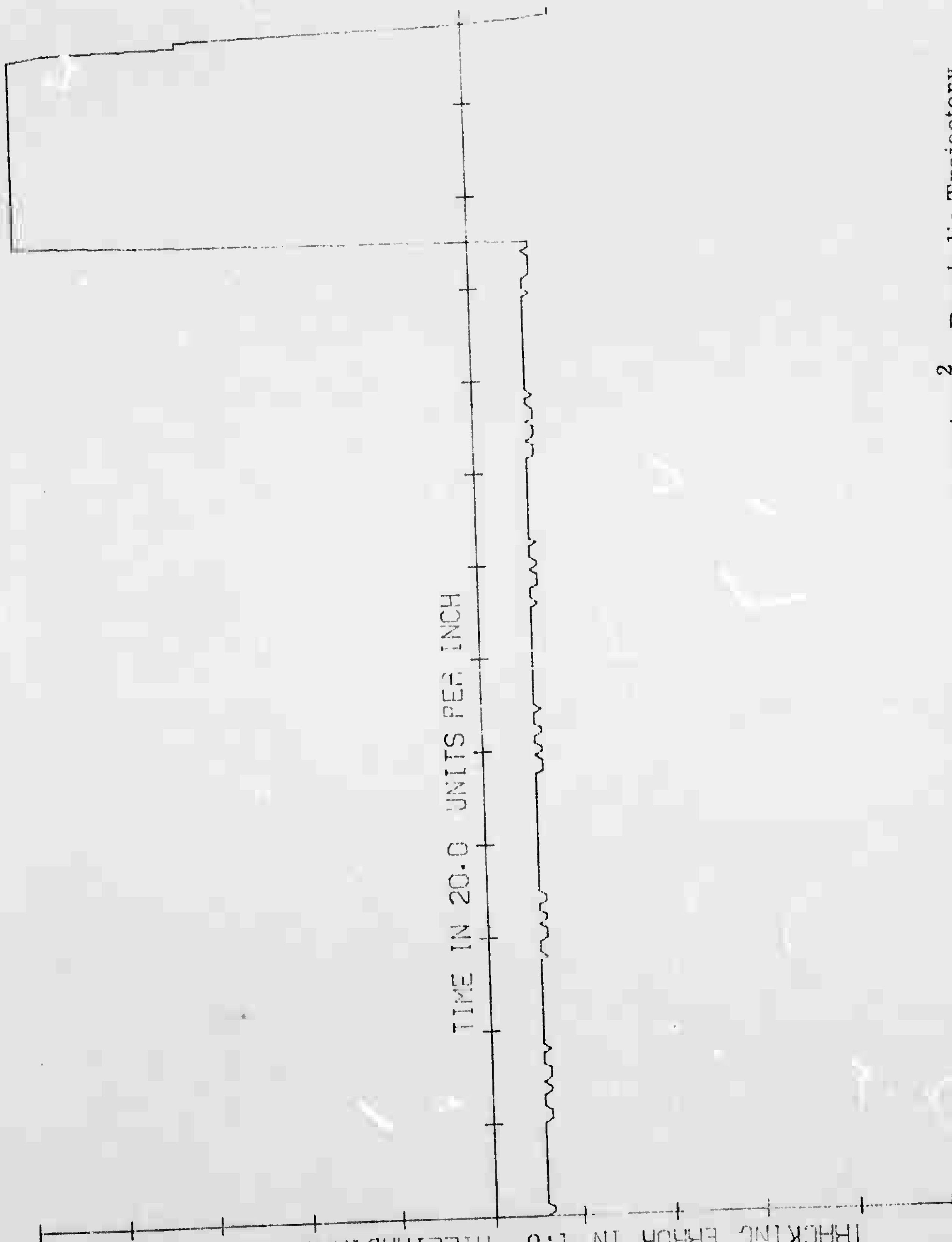


Figure 3-10. Tracking Error - Elevation Acceleration 13.67°/Sec^2 - Parabolic Trajectory

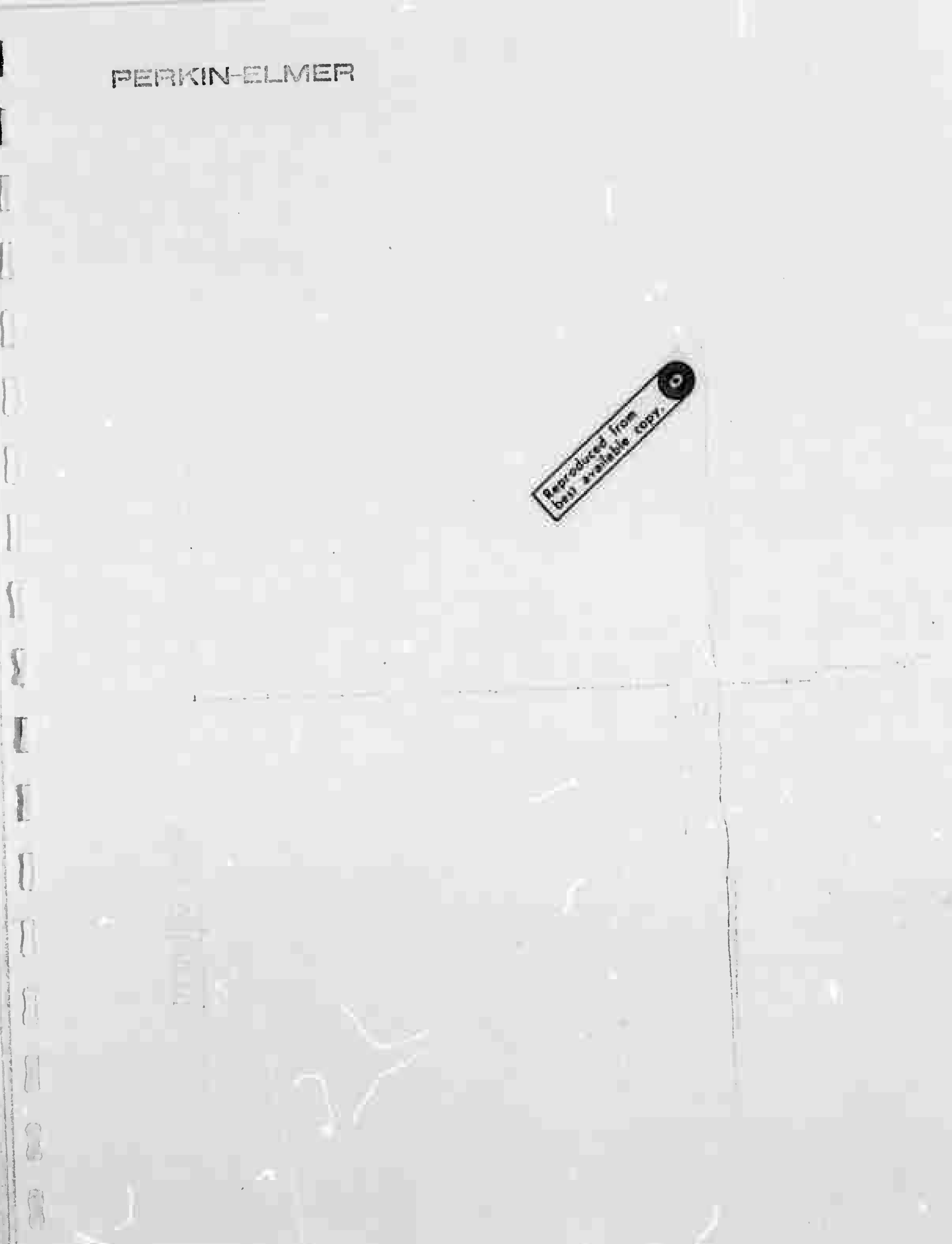


Figure 3-11. Tracking Error - Azimuth Ramp Input - 10°/Sec^2

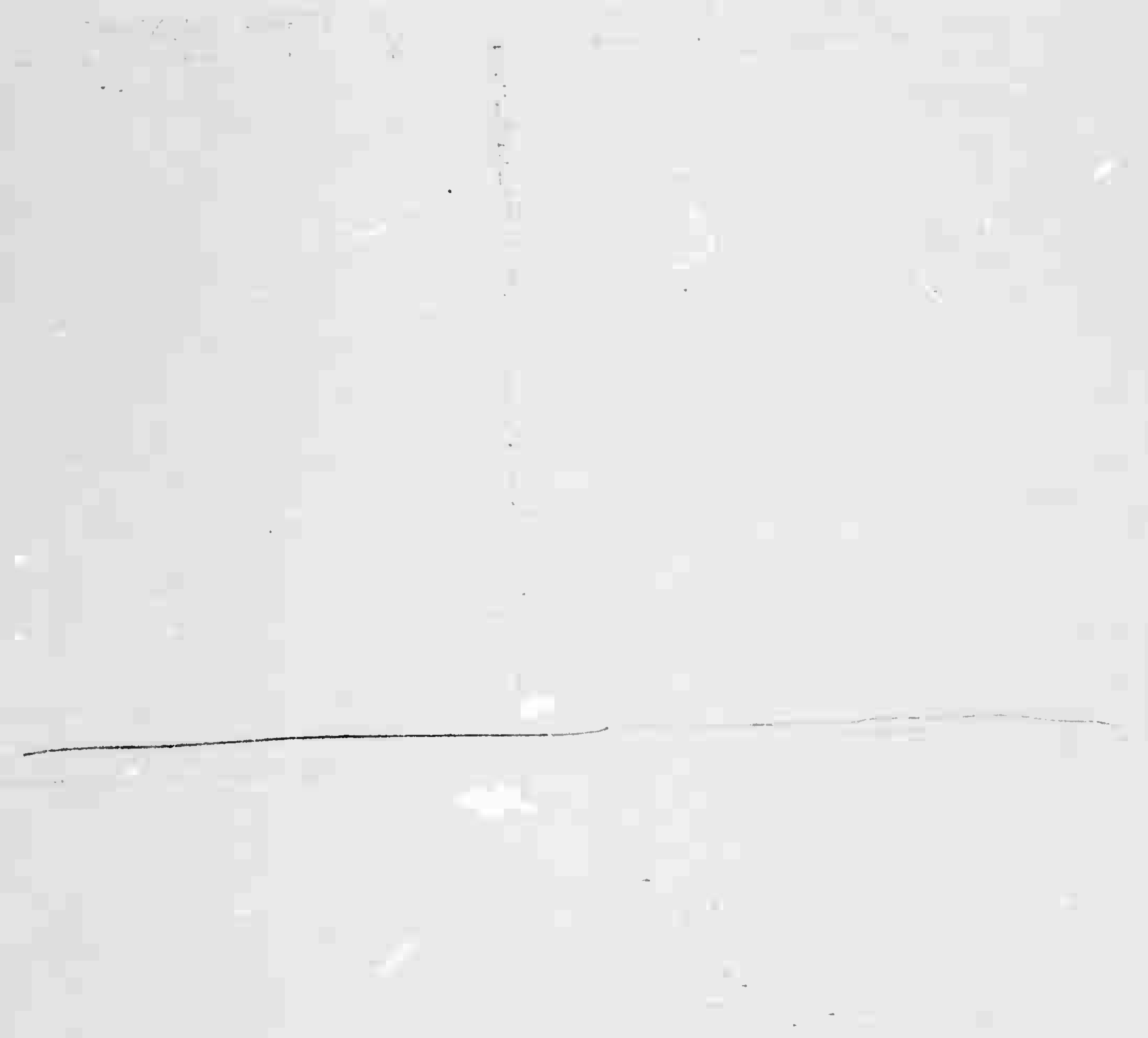


Figure 3-12. Tracking Error - Elevation Ramp Input - $10°/Sec^2$

3.8 CALIBRATION DATA - DUAL CHANNEL RADIOMETERS

The two dual channel radiometers used on Project GLOW are the System's main instrumentation for collection of signature data of reentry vehicles.

Accurate calibration of these instruments is a prime requirement of the operating contractor (General Electric) and is, of necessity, conducted by the present operator to his specifications and particular mode of evaluation.

This degree of accuracy requires the use of the System's digital data recording and printout equipment and the accurate measurement of the calibration source temperatures.

The objective of the field acceptance calibration was to perform a preliminary calibration of radiometer system sensitivity. To accomplish this, within the allocated two days, recordings and data were made and analyzed using only the System's analog recorder.

3.8.1 Summary

Radiometer A, channel 1 (PbS), and channel 2 (InSb) and radiometer B, channel 1 (PbS), met or exceeded all field specifications.

Radiometer B, channel 2 (InSb), developed a vacuum loss in the cooled detector assembly. System sensitivity was marginal, probably due to the condensation of moisture on the detector window.

Electrical functions (insertion of cal state pulses, the automatic gain mode, etc.) were operational on all channels.

Two items occurred during the last day and are noted:

1. Radiometer A, channel 2, developed 16 cycle coherent (non-random) noise. The noise figure was below system specification but should be investigated by the present operating personnel.

2. Temporary loss of Radiometer B, channel 2, signal from the pedestal during pedestal motion. Suspected cause is loss of conductor continuity in the pedestal cabling.

3.8.2 System Evaluation - Introduction

Performance of the dual channel radiometers, as an operational instrument (excluding the necessary and verified electronic system), is evaluated by the measurement of the system sensitivity and its dynamic range. This defines,

on a calibrated system, the instrument response to an optical signal coincident upon the detecting surface.

Analysis of recorded instrument output is then useable in determining the unknown optical signals' energy and spectral content.

3.8.2.1 System Sensitivity. Sensitivity is a measurement of the Noise Equivalent Power Density (NEPD) and is defined as the change in quiescent irradiance level at the radiometer entrance aperture to produce an output dc level equal to the output rms noise in a 1 cps Noise Equivalent Bandwidth.

For the radiometer system under consideration and using the GLOW calibration collimator:

$$NEPD = \frac{W_{max} \times F_s \times R \times T \times Q_r \times B \times P}{S/N}$$

where:

- S = DC signal in microvolts
- N = RMS Noise in a 1 cps Noise Equivalent Bandwidth
- W_{max} = Peak energy from radiation source
- F_s = Solid angle subtended by collimator field stop
- R = Ratio of energy at wavelength of spectral bandpass (filter of radiometer) center to peak energy of blackbody
- T = Collimator optical transmission efficiency
- Q_r = Transmission efficiency of EMR honeycomb on radiometer
- B = Spectral bandpass of radiometer filter used
- P = Ratio of detector peak response to radiometer filter (used) center wavelength.

also:

$$NEPD = H/_{S/N} \quad \text{watts/cm}^2$$

H = Irradiance at radiometer entrance aperture within spectral bandwidth of the applicable radiometer filter and at detector peak response

Values of H are calculated using various combinations of calibration blackbody temperatures, collimator field stops and radiometer filters.

3.8.2.2 Dynamic Range Capability. The plot of irradiance (H) vs the DC radiometer output (referenced to the detector input) is referred to as the dynamic range plot. This plot is generated by varying the value of irradiance and recording the radiometer output for each irradiance value.

The proper selection of collimator source temperatures and apertures will produce irradiance values from instrument threshold (NEPD) to saturation.

3.8.3 Test Procedure

(Figure 3-13 shows a simplified diagram of the test setup and signal flow.)

The radiometer and calibration collimator are optically coaligned and the test parameters (source temperature, field stop, and radiometer filter) are selected.

A recording is made on the system's visicorder while the optical energy impinges upon the detector. The optical energy is removed by closing the shutter; a manual calibrate pulse, representing a known electrical signal, is inserted. A comparison of the two signals determines the electrical value in rms microvolts generated by the optical energy.

System noise is recorded with the detectors active (the InSb detector is cooled; the PbS detector has bias applied) and using a higher speed visicorder setting. A manual calibrate signal is inserted and the resulting curve is analyzed to obtain an rms, 1 cps bandwidth, equivalent noise figure.

3.8.4 Results - Calibration Data

Using the test setup of paragraph 3.8.3, sufficient data was generated for the calculation of system sensitivity (NEPD), the 1 cps noise figure, and the dynamic range plots.

This was accomplished by utilizing collimator field stops one (1) through five (5) in conjunction with three (3) blackbody reference temperatures, 400°, 500°, and 700° Kelvin.

In addition, radiometer filter #3 was used as the reference filter in all cases.

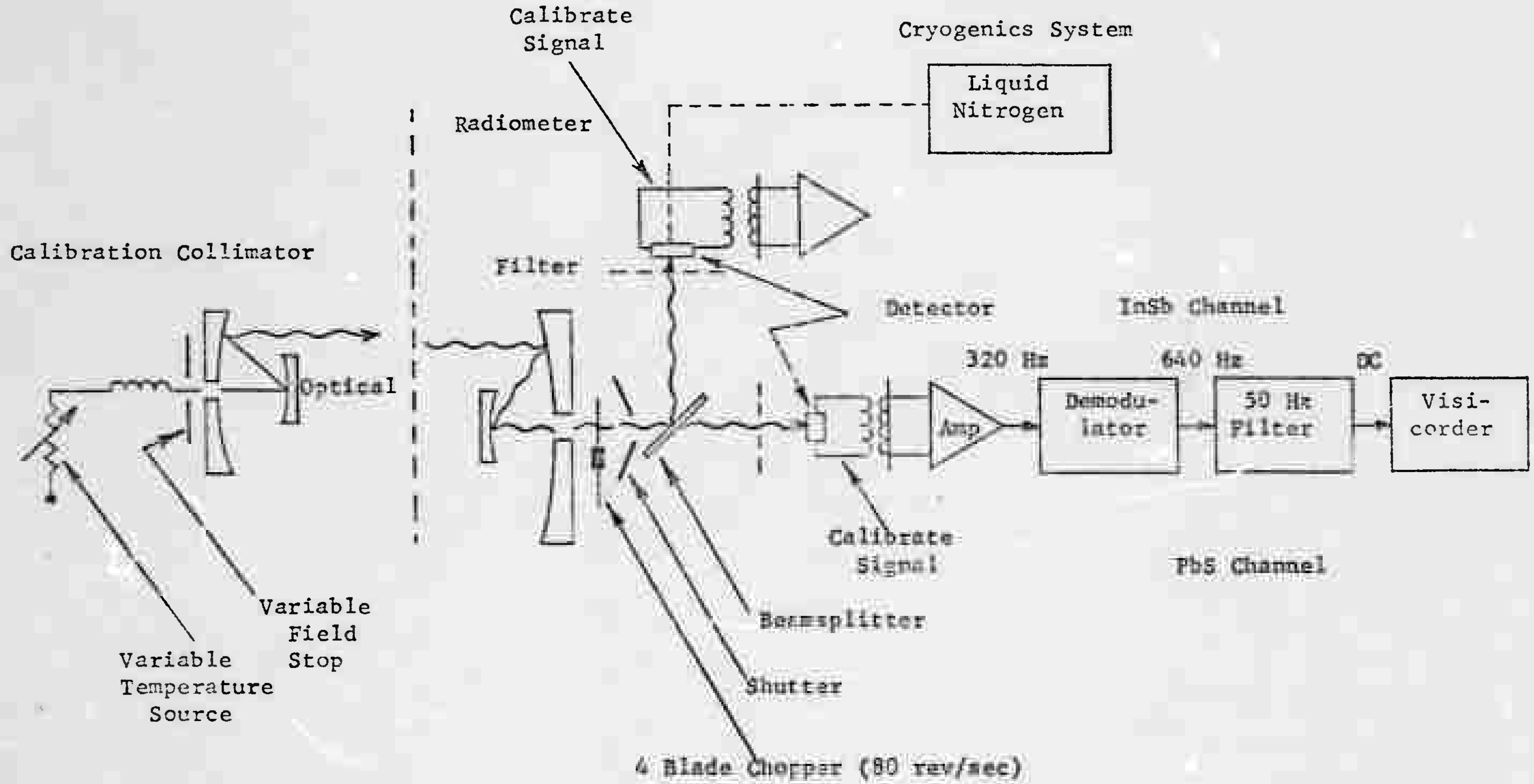


Figure 3-13. Simplified Diagram - Radiometer Optical and Signal Flow.

Table 3-6 summarizes the values obtained during these tests.

TABLE 3-6. PERFORMANCE SUMMARY

Radiometers	NEPD (watts/cm^2)	Noise Microvolts RMS, 1 cps
Rad A, Chan 1	4×10^{-14}	3.9
Rad A, Chan 2	2.2×10^{-13}	0.05
Rad B, Chan 1	5×10^{-14}	4.1
Rad B, Chan 2	3.5×10^{-14}	0.18

Figures 3-14 through 3-17 present the dynamic range curves plotted from the data runs.

With the exception of Radiometer A, Channel 2, which lost detector assembly vacuum, the above table indicates performance meeting or exceeding field specifications for this instrumentation.

3.8.4.1 Calibration Data Comments

1. The use of the analog Visicorder (instead of the DDH system, as indicated in the opening objective), is sufficient only for preliminary or rough calibrations. This recorder exhibits nonlinearity of signal level reproduction with the same gain setting, when two signal levels differ by 20 - 30:1. Therefore, when using the highest radiometer calibrate insertion (10,000 μv, Channel 1) to measure a 200,000 - 300,000 μv signal, errors will be introduced. In addition, the use of a measuring scale for ratio scaling (see paragraph 3.8.5.1) will introduce a human factor error.

2. The blackbody reference calibration dial was assumed accurate. Accurate calibrations require known temperatures; the preferred method is to measure the temperature with a bridge instrument or pyrometer, when applicable. As an example, a difference of ±5° Kelvin at 500°K will generate a change of energy levels of approximately 10 percent. This, of course, can lead to data points, taken at different temperatures, not falling in a straight line pattern on the log-lag paper used.

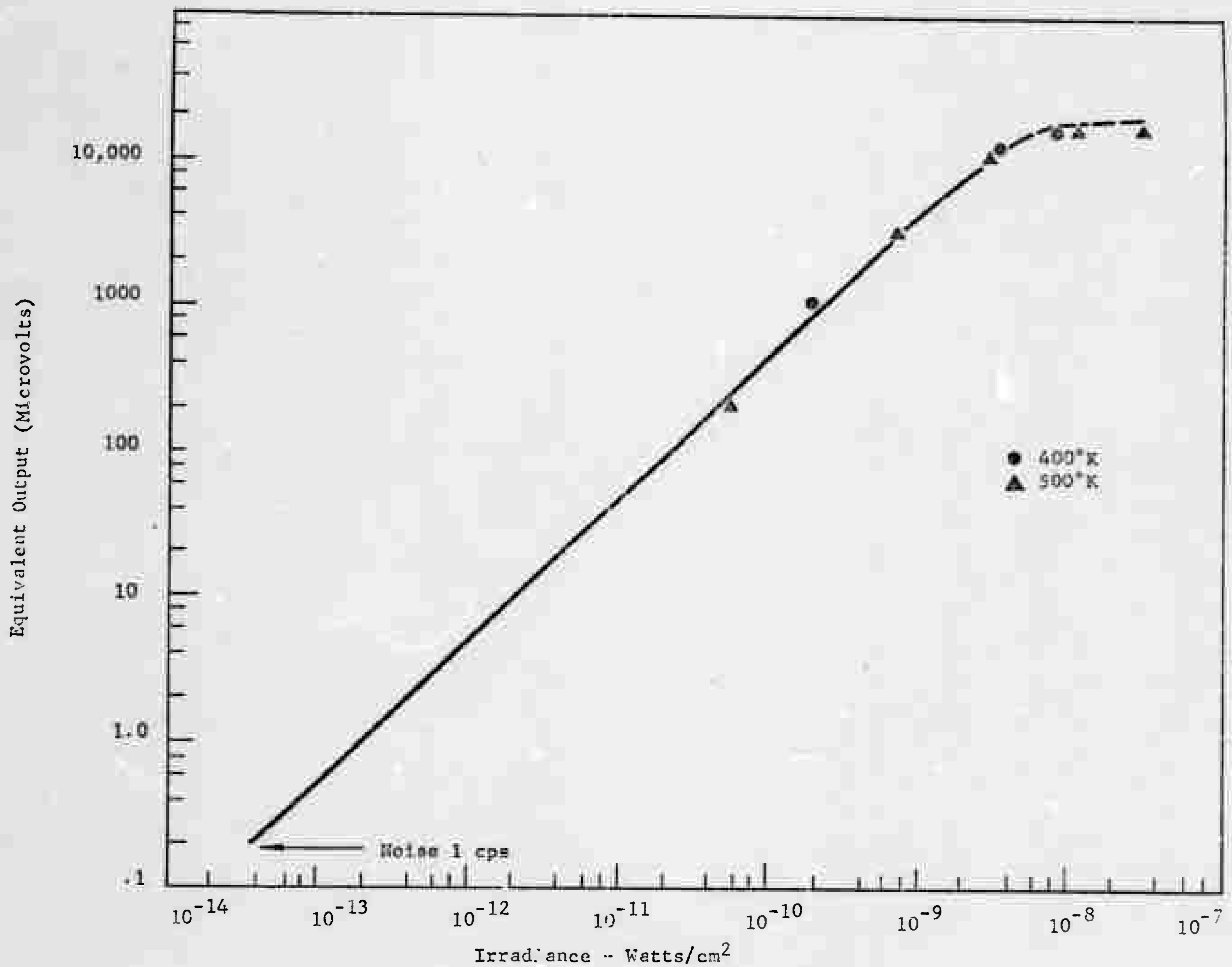


Figure 3-14. Dynamic Response - Radiometer B, Channel 2

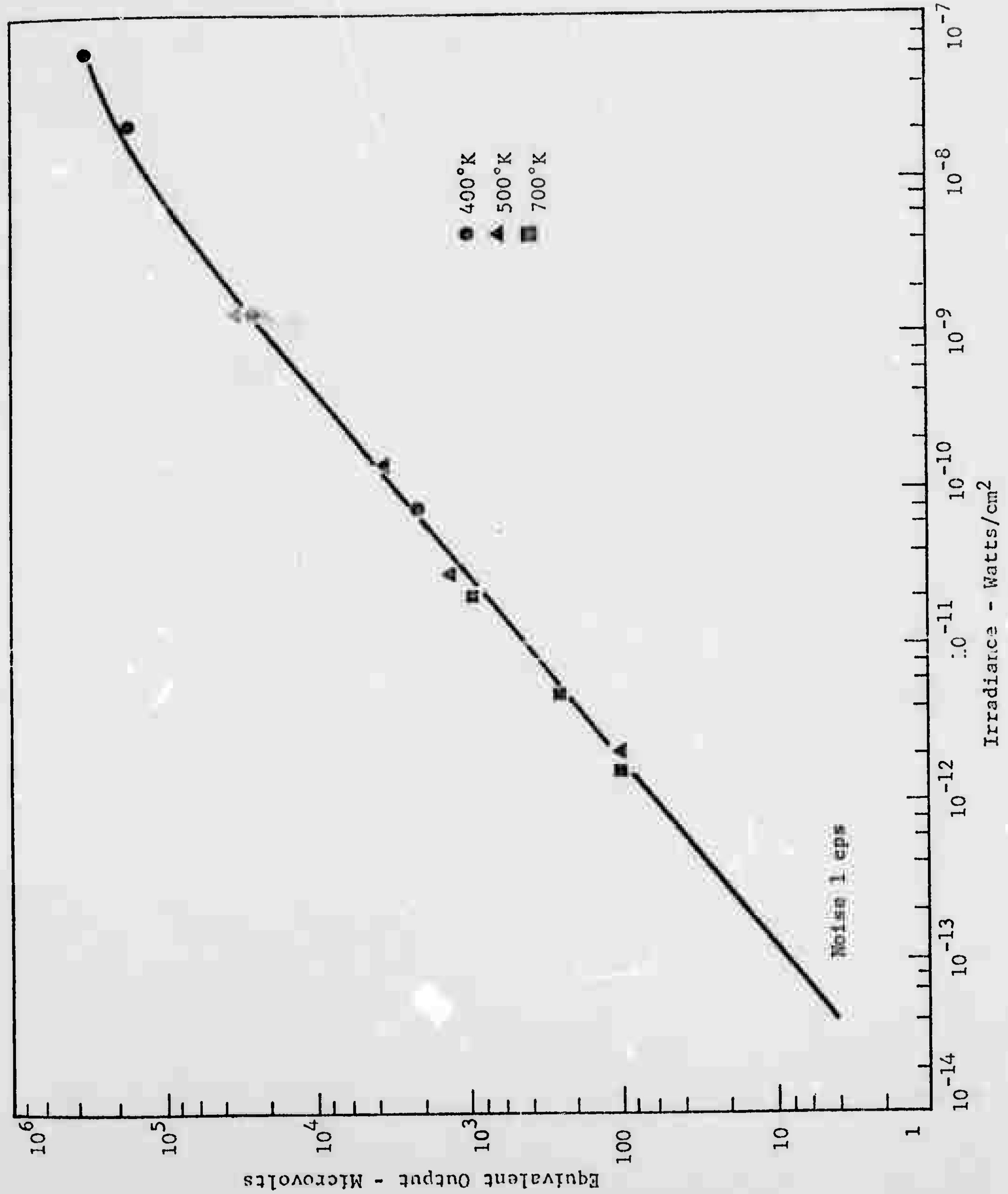


Figure 3-15. Dynamic Response - Radiometer A, Channel 1

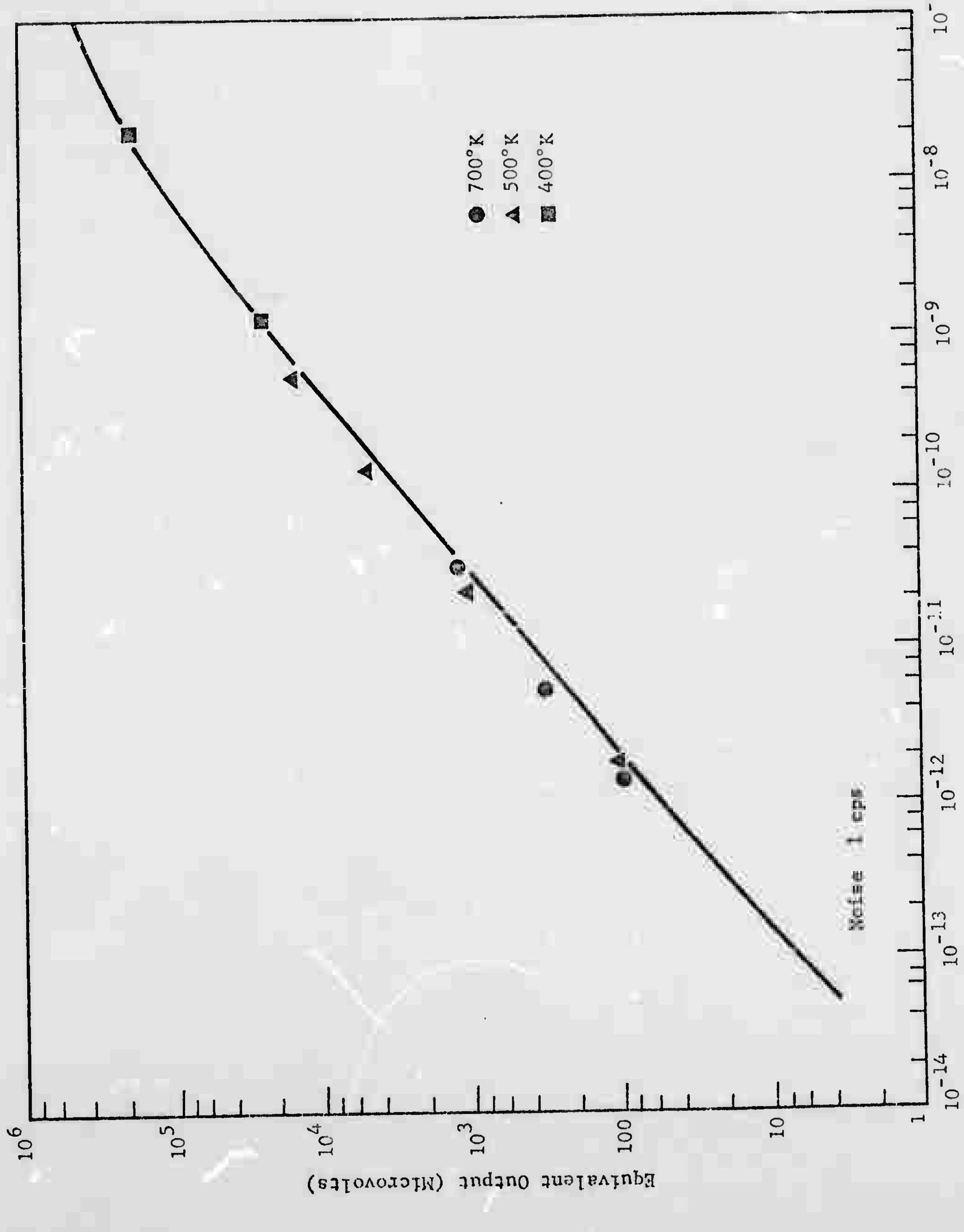


Figure 3-16. Dynamic Response - Radiometer B, Channel 1

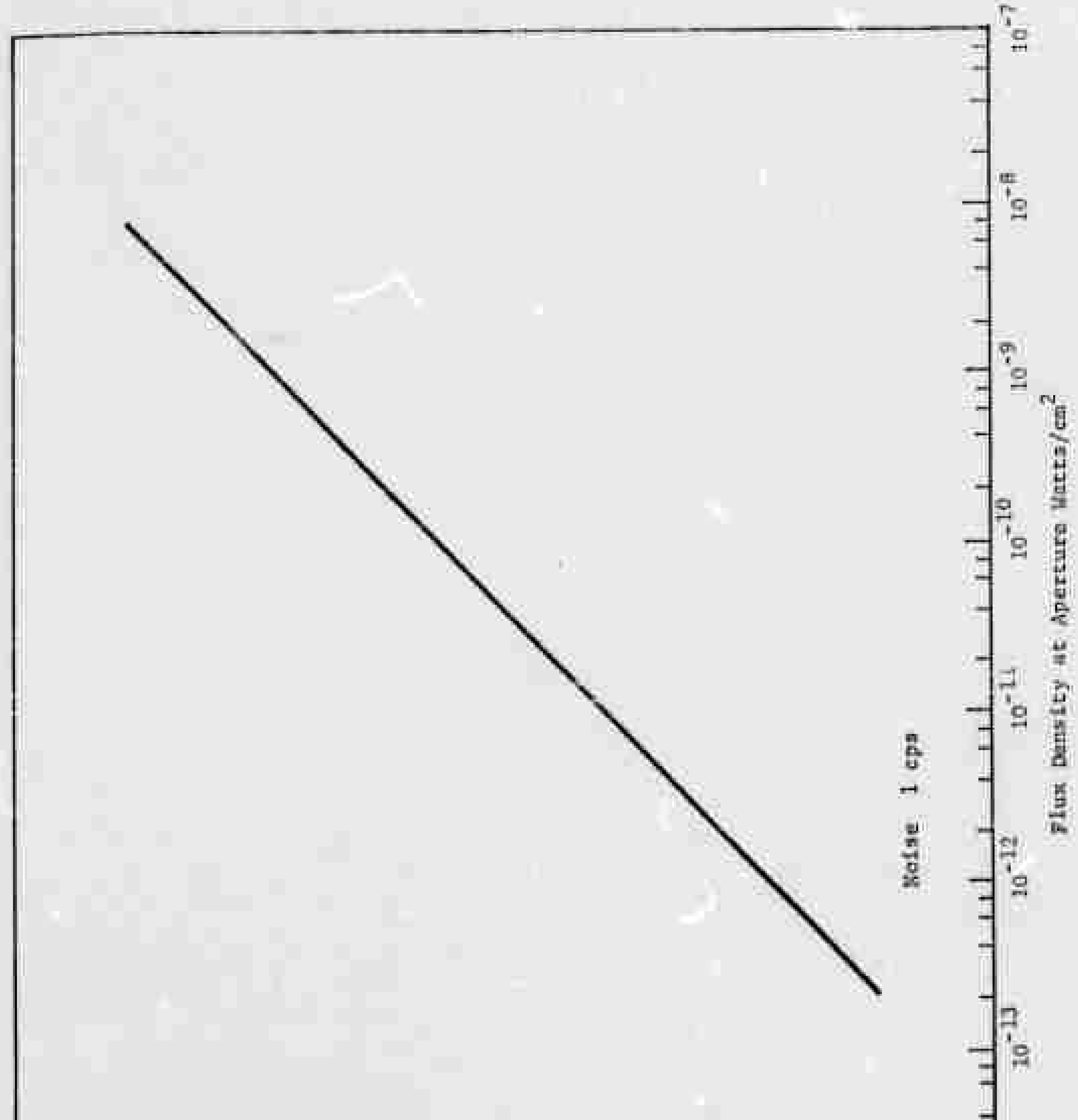


Figure 3-17. Dynamic Response - Radiometer A, Channel 2

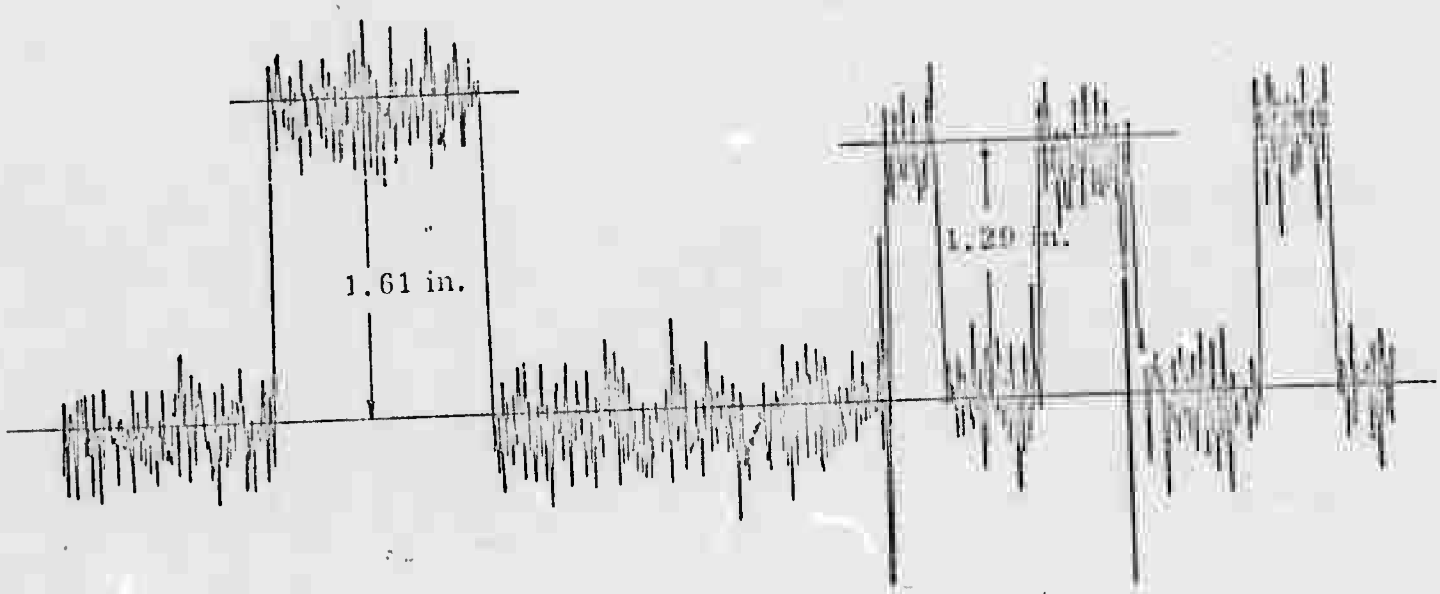
3.8.5 Typical Analysis of Visicorder Recordings

Paragraphs 3.8.5.1, 3.8.5.2, and 3.8.5.3 indicate the methods used in the calibration.

The visicorder charts (figures 3-18 and 3-19) are actual reproduction of curves run at Kwajalein. They have been mechanically darkened to enable their reproduction for this report but are unchanged in any other way.

3.8.5.1 Signal Evaluation (See Figure 3-18.)

Radiometer A - Channel 1, Filter 3
Collimator Temperature - 500°Kelvin,
Collimator Field Stop - Number 1



20db Cal = 100μv

$$\text{Signal} \approx \frac{1.29}{1.61} \times 100 = 80.3\mu v$$

Figure 3-18. Radiometer Signal Evaluation

3.8.5.2 Noise Evaluation (See Figure 3-19.)

Radiometer A - Channel 1 - Bias On, Shutter In -
Manual Gain Equal to Gain of Section 3.8.5.1 - Signal Run

3.8.5.3 Noise Equivalent Power Density (NEPD). Utilizing the data of paragraphs 3.8.5.1 and 3.8.5.2, the NEPD can be calculated,

$$NEPD = H/_{S/N} \quad \text{where } H = \text{Irradiance in watts/cm}^2$$

$$= 2.83 \times 10^{-12}$$ (for collimator field stop #1, Temp = 500° Kelvin and Radiometer Filter #3)

$$= \frac{2.88 \times 10^{-12}}{80.5/2.03}$$

$$= 7.27 \times 10^{-14} \text{ watts/cm}^2\text{; 1 cps bandwidth, RMS value}$$

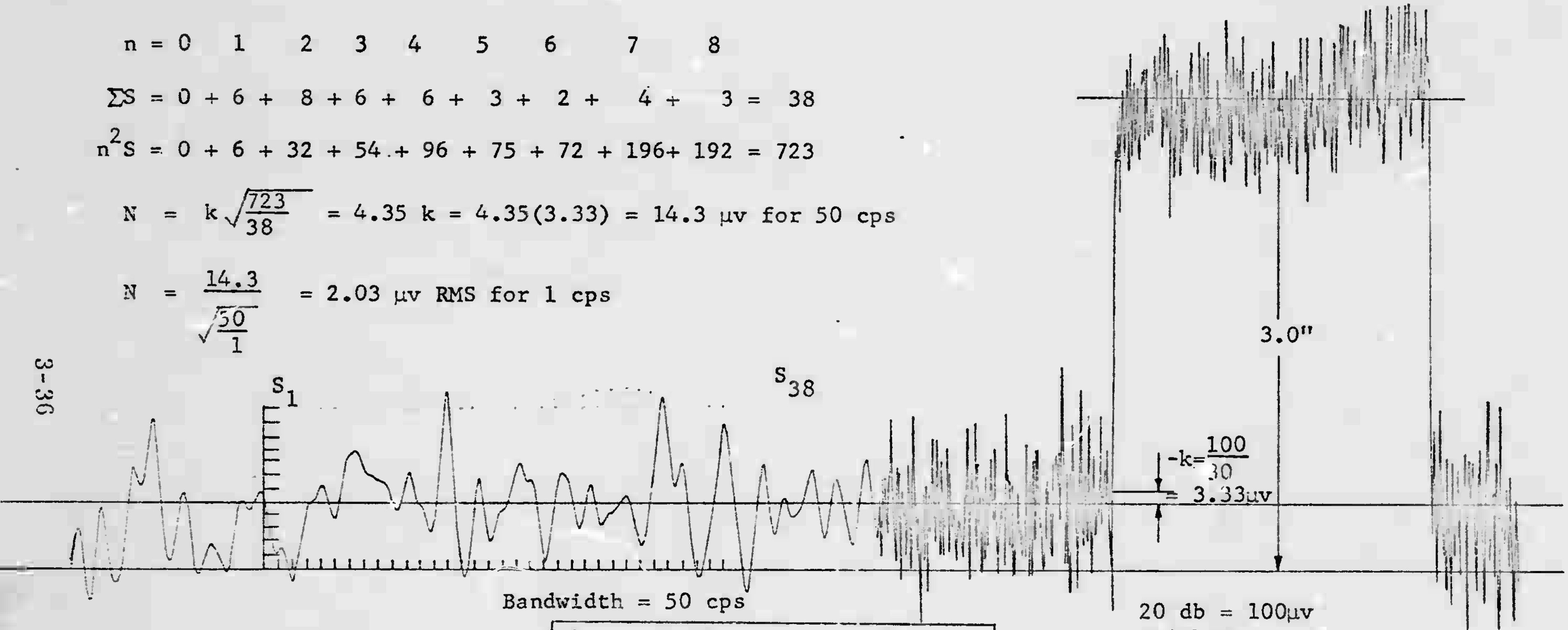
n = 0 1 2 3 4 5 6 7 8

$\Sigma S = 0 + 6 + 8 + 6 + 6 + 3 + 2 + 4 + 3 = 38$

$n^2 S = 0 + 6 + 32 + 54 + 96 + 75 + 72 + 196 + 192 = 723$

$$N = k\sqrt{\frac{723}{38}} = 4.35\ k = 4.35(3.33) = 14.3\ \mu v \text{ for } 50 \text{ cps}$$

$$N = \frac{14.3}{\sqrt{\frac{50}{1}}} = 2.03\ \mu v \text{ RMS for } 1 \text{ cps}$$



$$RMS_{value} = \sqrt{\frac{n_1^2 S_{m_1} + m_2^2 S_{m_2} --- + n_\ell^2 S_{n_\ell}}{S_{m_1} + S_{n_2} --- + S_{n_\ell}}}$$

Noise = RMS x (k); where K = Scale Factor for n in µv

Figure 3-19. Radiometer Noise Evaluation

ABBREVIATIONS

ACCEL	Acceleration
AGC	Automatic Gain Control
AM	Amplitude Modulated
AMICOM	United States Army Missile Command
AZ	Azimuth
B	Bandwidth
BOR	Beginning of Record
BOI	Bits per Inch
BTU	British Thermal Unit
CAL	Calibrate
CHAN	Channel
CM	Centimeter
COBI	Coded Biphase Transmission
COM	Command
COMP	Compensator
CONST	Constant
CPS	Cycles per Second
DB	Decibel
DDH	Digital Data Handling
DDR	Data Digitizing and Recording
DR	Discrimination Radar
EFL	Effective Focal Length
EL	Elevation
EMR	Electro-Magnetic Radiation

ABBREVIATIONS (Continued)

EOF	End-of-File
EOM	End-of-Message
EOR	End-of-Record
G	Gravity
GFE	Government-Furnished Equipment
GND	Ground
HV	High Voltage
HZ	Hertzian Wave
ICC	Interstate Commerce Commission
InSb	Indium Antimonide
IO	Image Orthicon
I/O	Input/Output
IPS	Inches per Second
I/R	Infrared
IRIG-B	Time Code (Type)
K	Kelvin
KTS	Kwajalein Test Site
KW	Kilowatt
LOC	Location
LST	Local Standard Time
MAG	Magnetic
MGC	Manual Gain Control
MM	Millimeter
MR	Milliradian
MRAD	Milliradian
MS	Millisecond
N/A	Not Applicable

ABBREVIATIONS (Continued)

NEPD	Noise Equivalent Power Density
PbS	Lead Sulphide
PECO	Perkin-Elmer Corporation
POE	Port of Entry
POS	Position
P.P.	Peak to Peak
PPS	Pulse per Second
PT	Point
R	Range
RAD	Radiometer
RC	Resistor Capacitor
RECT	Rectified
RF	Radio Frequency
RFI	Radio Frequency Interference
RMS	Root Mean Square
RPS	Revolution Per Second
R/V	Reentry Vehicle
SIG	Signal
SYN	Synchronous
TACH	Tachometer
TAN	Tangent
TCKG	Tracking
TD	Tracking Data
TMCC	Time Multiplexed Communication Channel
TRAJ	Trajectory
TTR	Target Tracking Radar
V	Velocity
WSMR	White Sands Missile Range

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Report No.	Author	Title	Classification
7387	Benson	Study Report for WSMR Optical Reentry Instrumentation System - Project GLOW, 15 July 1963	U
7468	Fencil	Servo System Analysis for Project GLOW	U
7488	Finn	RFI Protection for GLOW	U
7563	Benson	Program GLOW, Semi-Annual Technical Report	U
7754	Benson	Program GLOW, Semi-Annual Technical Report	U
7861	Stahl	GLOW System Expansion	U
7871	Antonetz	Final Report - GLOW Long-Lead Items	U
7888	Sachs	Calibration Collimator for Project GLOW Instrumentation Final Report	U
7913	Sachs	Dual Channel Radiometer System for Project GLOW Final Report	U
8015	Stahl	GLOW Final Report	U
8018	Fencil	GLOW Jitter Test Report	U
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8087	Stahl/Benson	Semi-Annual Technical Report Program GLOW System, 15 July 1965	U
8088	Stahl	Semi-Annual Technical Report Program GLOW Field Contract	U
8126-021	Backus	GLOW Quick Look Report Athena Mission 021	U
8126-025	Backus	GLOW Quick Look Report Athena Mission 025	U
8126-026	Backus	GLOW Quick Look Report Athena Mission 026	U
8126-029	Backus	GLOW Quick Look Report Athena Mission 029	U
8126-030	Backus	GLOW Quick Look Report Athena Mission 030	U
8126-031	Backus	GLOW Quick Look Report Athena Mission 031	U
8126-035	Backus	GLOW Quick Look Report Athena Mission 035	U
8265	Barnard	GLOW Jitter Package	U

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8435	Stahl	PAS Trajectory Data Analysis	U
8441A	Criscuolo	Mithras Tracker Evaluation Report	U
8622	Backus	Computer Extension to GLOW System, 14 December 1966	U
8693	Stahl	Final Acceptance Test Procedure for the GLOW System at Kwajalein, 16 March 1967	U

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SCIENTIFIC DATA SYSTEMS (SDS) - SOFTWARE

SDS No.	Title
000014C	DEBUG
000017C	Media Conversion Routine
000018C	Binary Dump
000020	Universal Loader
000022B	RECON
004008	P and S Register Tester
012001C	FORTRAN Run-Time Debug
012006	910 Symbol Mnemonic Table
012007	9300 Symbol Mnemonic Table
012012	Symbol Loader
012013C	AID
012014	SYMBOL Reproduce and Update Routine
012027	SYMBOL
020012C	Paper Tape Reproducer
020014	Memory Tape-Out
020018	Checksum Dump Routine
020019B	PTYIO
020020	Binary Paper Tape Bootstrap
020021	Binary Format Converter
020022	Binary Format Converter
020023	Symbol Typewriter Listing Subroutine
020024B	Paper Tape Read or Typewriter Symbol Input
020025	Paper Tape Punch Binary Output
020026B	FORTRAN II Library Program
022002B	FORTRAN II Memory Save

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SCIENTIFIC DATA SYSTEMS (SDS) - SOFTWARE
(Continued)

SDS No.	Title
024001	Paper Tape Photo-Reader Test
024002	SATT
040007	Mag. Tape Symbol Input
112005F	910 FORTRAN II System
202003D	910 Prog. Operator's Package
202008K	920 Fortran
202014B	FORTRAN II Format - Statements - Run Time
202015	FORTRAN II 9 Continuation Statements
202017	FORTRAN II 3 Continuation Statements
202018	FORTRAN II Hollerith Literals Modification
303001B	Double Precision Floating Point Programmed Operator
304004	930 Examiner Diagnostic
44003B	Mag. Tape Test
44004B	Mag. Tape Exerciser
503001B	Paper Tape and Typewriter Subroutine
524001B	Extended Mode I/0 Test
544001C	Mag. Tape Exerciser

APPENDIX A

STATION LOG SUMMARY

APPENDIX A

STATION LOG SUMMARY
(Kwajalein Test Site - Marshall Islands)

MON. 10 OCT. 1966

First crew member arrived on Red Tail* - Weather: Clear and warm.

TUES. 11 OCT. 1966

Began liaison with local KTS support - Weather: Clear and warm.

WED. 12 OCT. 1966

Went to Global Supply, machine shop - Weather: Scattered clouds; occasional showers.

THURS. 13 OCT. 1966

Three more members of crew arrived - Weather: Scattered clouds; occasional showers.

FRI. 14 OCT. 1966

Crew began site preparation for expected arrival of ship, "American Bear."

SAT. 15 OCT. 1966

Received word "American Bear" would not arrive until 21-22 Oct. Started gathering equipment (wiring supplies, etc.) from Global Supply. Weather: Cloudy; showers.

MON. 17 OCT. 1966

"American Bear" to arrive 22 Oct. Initiated search for materials to seal concrete floor and wooden planks for scaffolding.

TUES. 18 OCT. 1966

Building swept and mopped. Transportation to and from site (by local taxi) time consuming. Weather: Occasional showers.

---

*Northeast Airlines Chartered Flight - Honolulu to Kwajalein.

WED. 19 OCT. 1966

Continued work in building. Tried to locate old bicycles to ease transportation problem. Weather: Clear.

THURS. 20 OCT. 1966

"American Bear" to arrive tomorrow.

FRI. 21 OCT. 1966

Our equipment will be unloaded Sat. and Sun.; will work both days if required. Weather: Occasional clouds; showers.

SAT. 22 OCT. 1966

Began receiving and checking dome and equipment crates from aboard ship "American Bear." Utility van not on board.

SUN. 23 OCT. 1966

Finished unloading equipment from "American Bear." All crates and dome accounted for. Damage to one crate of test equipment and three cable reels. Crate containing 24-inch mirror dropped on pier.

MON. 24 OCT. 1966

All equipment crates and dome delivered to GLOW building; had trouble getting main door off. Checked damaged crates, but no apparent damage to cables or equipment. Work started by Army Engineers to modify collimator concrete pedestal and sealed hole No. 2 on roof.

TUES. 25 OCT. 1966

Unpacked all test equipment and tool crates. Test equipment received in good shape.

WED. 26 OCT. 1966

Cleared west side of building in preparation for floor treatment with sealant. Unpacked screen room material. Some water damage to paint was noted in two crates. One 4 foot section of ceiling and one 4 foot by 8 foot section of wall has water damage to paint. Also, front door rusted.

THURS. 27 OCT. 1966

Pictures were taken of damaged screen room sections and door. Screen room material was sorted and inventory of all tagged property was catalogued. The floor was leveled around the drain where screen room will be located. Weather: Rainy.

FRI. 28 OCT. 1966

Started preparing for screen room erection, dome ring, and laying floor sections.

SAT. 29 OCT. 1966

Finished laying screen room floor and began putting up walls. Weather: Cloudy; occasional rain.

MON. 31 OCT. 1966

Screen room walls were finished; phones were installed in office. Ditch digger cut building ground cable by mistake, but it was repaired with a clamp and welded. Received shelving material. Discovered roof leak after Army Engineers worked on hole cover.

TUES. 1 NOV. 1966

Began screen room ceiling assembly. Installed dome ring; is level to 1/8 inch. Finished storage area; are in process of constructing temporary shelving for test equipment and tools. Found one section of screen room ceiling 5 inches too wide.

WED. 2 NOV. 1966

Cleaned up building and finished storing test equipment. Weather: Rainy throughout the day.

THURS. 3 NOV. 1966

Worked on screen room ceiling.

FRI. 4 NOV. 1966

Worked on screen room ceiling.

SAT. 5 NOV. 1966

Finished screen room assembly. Couldn't torque screws properly due to lack of proper tools. Questioned torque specification of 140 inch pounds.

SUN. 6 NOV. 1966

Fabricated scaffold.

MON. 7 NOV. 1966

Painted floors and installed screen room air ducts. Weather: Rainy.

TUES. 8 NOV. 1966

Painted floors and laid out hydraulic power unit.

WED. 9 NOV. 1966

Painted floors and installed hydraulic power unit. Received equipment from ship "Steel Rover."

THURS. 10 NOV. 1966

Received pedestal and utility van from ship; started unloading utility van and laid out electrical hardware for screen room.

FRI. 11 NOV. 1966

Located electrical fittings for screen room and continued unloading utility van.

SAT. 12 NOV. 1966

Wired screen room; fixed crane on roof; unloaded utility van. B-50 tower emplaced on mezzanine; located electrical fittings.

MON. 14 NOV. 1966

Worked on screen room wiring. Unloaded van. Received more crated items from shipping. Major Burchette and M.M. Jernigan visited the site; test equipment and calibration requirements were discussed. Mr. Jernigan was given one copy of the GLOW Test equipment list.

TUES. 15 NOV. 1966

Screen room wiring layout was reworked. Legs were mounted on the pedestal and disconnected from the carriage. Started layout of sighting station; cleaned up equipment staging. Range support was discussed with Mr. F. Barberia and Mr. Rodgers of KTS, and with Mr. Sims and Mr. Matson of Global and C.O.E.

WED. 16 NOV. 1966

Pedestal and dome were placed in position on the roof. B-50 cover ring was installed and screen room wiring continued. C.O.E. crew worked on latch for pedestal hole No. 2. Pictures were taken of the pedestal and dome construction.

THURS. 17 NOV. 1966

Finished wiring screen room except hook-up to line filters and fuse box. (Wiring for computer 3Ø to be accomplished when computer arrives.) Constructed temporary storage facility.

FRI. 18 NOV. 1966

Work load extremely heavy due to unexpected electrical work in building.

SAT. 19 NOV. 1966

Work orders for mounting hydraulic power unit and screen room junction box were initiated. All phases of site installation continued. Weather: For the past week, poor; frequent rain showers.

MON. 21 NOV. 1966

Processed work orders for screen room junction box and hydraulic power unit stand. Mechanical design for pedestal work platform progressing. Weather skirt on astrodome is almost completed. Located two old bicycles; will order more.

TUES. 22 NOV. 1966

Hydraulic power unit stand was received; plan to install it tomorrow. Continued installation of dome and dome platform. Have not been able to work on electrical requirements due to manpower shortage.

WED. 23 NOV. 1966

Installed hydraulic power unit; reorganized storage area. Started external screen room wiring.

THURS. 24 NOV. 1966

Continued work on power installation and tied down hydraulic power unit. Started construction of cable raceway.

FRI. 25 NOV. 1966

Collimator railbed and console were installed in the collimator shed. Continued wiring main power to screen room.

SAT. 26 NOV. 1966

Screen room main power was hooked up; test checkout was performed. Installed another raceway and hooked up the hydraulic power unit and power lines. Weather: Still poor.

MON. 28 NOV. 1966

Continued to work on cable raceway and hydraulic power unit lines. Holes are being drilled into the mezzanine floor for the hydraulic lines and control cable.

TUES. 29 NOV. 1966

Continued work on cable raceway; also continued hydraulic power unit electrical hook-up. Initiated cleanup and salvage for lumber from shipping pallets. Work order is in process to move the 400 cycle converter unit into a temporary position inside the building.

WED. 30 NOV. 1966

Completed power hook-up to hydraulic power unit. Moved the 400 cycle converter into the building. Work started on work platform in the dome.

THURS. 1 DEC. 1966

Converter was installed but is not operating. Work started on pedestal platform. Ray Proof representative arrived to perform RF shielding test of screen room.

FRI. 2 DEC. 1966

Located and stopped all RF leaks in screen room. Continued troubleshooting the 400 cycle converter. Continued work on pedestal platform.

SAT. 3 DEC. 1966

Located trouble with 400 cycle converter; a voltage sensing relay circuit was to blame. Made temporary modification to get converter working. Ordered part for permanent fix. RF testing of screen room completed and passed specification.

MON. 5 DEC. 1966

Finished wiring extension from dome servo unit to hydraulic J-box. Worked on platform. Painted dome base ring with sealant. Received and painted I-beams for screen room. Performed an estimate for outside work to hook-up utility van and converter. Made new supports for screen room cable raceway. Cleaned site area. Discussed construction of converter shelter and power requirements with Army Corp of Engineers representative.

TUES. 6 DEC. 1966

Fabricated and painted pedestal platform frame; plywood was laid down in sections. Wired dome servo J-box and worked on additional spare parts storage space.

WED. 7 DEC. 1966

Continued work on platform. Painted base of dome to seal leaks. Wired switch and exhaust fan in screen room. Weather: Continuous rain for the past week; average rainfall was approximately 1 inch per day.

THURS. 8 DEC. 1966

Replaced broken NE-32 in converter relay assembly. Completed work platform; mounted lead weights on pedestal. Processed work request for hoist repair. Removed light fixture; installed electric outlet at sighting station.

FRI. 9 DEC. 1966

Sections of computer shipment arrived and were partially unloaded due to inclement weather; remainder will be unloaded tomorrow.

SAT. 10 DEC. 1966

Unloaded and uncrated remainder of computer shipment. Keys missing from writer but were found loose in crate. Started steel beam drilling; worked on hydraulic lines and RF antenna.

MON. 12 DEC. 1966

Completed steel beam drilling; continued to work on RF antenna and hydraulic lines. General wiring and wiring of utility van were discussed with Army Corp of Engineers.

TUES. 13 DEC. 1966

Started wiring (power) computer system. Dismantling and drilling of 7/8 inch diameter holes in 24-inch mirror base casting was started but, not having proper equipment, it was decided to contract the work to Global shops. Continued work on hydraulic unit; painted RF antenna. Oil for hydraulic unit not available yet.

WED. 14 DEC. 1966

Holes were drilled through the base by our own man with Global equipment. Continued general work on the hydraulic unit.

THURS. 15 DEC. 1966

Used Global crane to repair hoist and attaching guy lines. Reassembled 24-inch mirror and boxed it in collimator shack. Computer wiring is progressing.

FRI. 16 DEC. 1966

Hydraulic lines and computer wiring continued. Spare parts are being stored.

SAT. 17 DEC. 1966

Worked on Spectrum Analyzer antenna tower. Wiring in computer area is progressing. Cleaned storage area; inventory retaken.

MON. 19 DEC. 1966

Worked on B-50 installation and RF antenna. Discovered part of antenna was missing.

TUES. 20 DEC. 1966

Worked on B-50 installation.

WED. 21 DEC. 1966

Worked on B-50 installation and public address system. Cleaned up site; checked EL data unit malfunction. Need maintenance information.

THURS. 22 DEC. 1966

Continued B-50 installation; cleaned up site. Fixed weather strip on main door.

PERKIN-ELMER

FRI. 23 DEC. 1966

Painted B-50 tower assembly.

MON. 26 DEC. 1966

Made additional storage racks; straightened area for better work space.

TUES. 27 DEC. 1966

Started cleaning equipment to remove rust, etc.

WED. 28 DEC. 1966

Continued work on cleaning and maintenance.

THURS. 29 DEC. 1966

Regreased utility van; spot-painted equipment mounted on roof.

FRI. 30 DEC. 1966

Continued maintenance of equipment. Weather: Rain during December was approximately 31 inches.

TUES. 3 JAN. 1967

"Pacific Bear" due to arrive with Instrument Van about 5 Jan. 1967.

WED. 4 JAN. 1967

Received computer frame; shock mounts and crate were damaged. Took pictures of damage.

THURS. 5 JAN. 1967

Received Van, Potter tape unit, and computer equipment. Some damage was noted, especially to the underside of the Van. Also, received the Dewar; some corrosion was found around the fittings. Turned on computer power.

FRI. 6 JAN. 1967

Worked on teletype with assistance from Kentron teletype repairman. Made minor repairs to computer.

SAT. 7 JAN. 1967

Completed work on teletype. Washed the Instrument Van and painted some areas of the dome. Received and inventoried spare parts.

MON. 9 JAN. 1967

Computer work progressed. Building was cleaned up in preparation for receiving the Instrument Van.

TUES. 10 JAN. 1967

Emplaced Instrument Van in building. Unpacked the Van and discovered damaged area in top. Pictures were taken. Computer work progressed.

WED. 11 JAN. 1967

Cable platform under the Van was fabricated. Emplaced cables from pedestal to Van. Cleaned out the Van; installed chassis in console. Computer work continued.

THURS. 12 JAN. 1967

Completed laying cables to Van and pedestal. Global started working on air conditioning ducting. Computer work continued.

FRI. 13 JAN. 1967

Laid 400 cycle power cable to Van. Cleaned up site. Continued work on computer and teletype.

SAT. 14 JAN. 1967

More crates delivered by "Pacific Bear." Fabricated and painted platform with stairway for Instrument Van side entrance. Worked on outfitting the utility Van and computer room. Replaced door to tape console (2AT3) with plexiglass; glass was broken during shipment.

SUN. 15 JAN. 1967

Continued work on Instrument Van and computer room.

MON. 16 JAN. 1967

Unpacked and sorted crates. Continued work on outfitting the Utility Van. Began screen room to Van cable hook-up. Discovered that the Van air conditioning unit mounts were broken; have requested a work order for Global metal shop to fabricate a new pair.

TUES. 17 JAN. 1967

Turned on Van power with the exception of the DDH racks; all power racks are okay. Operated the pedestal; adjustment was required in elevation (also, elevation limits and mount interlocks did not work.) Repaired broken wires in cable 3J1. Installed B-50 MITOC unit, 60 cycle ac. Public address system hook-up progressed. Continued work in computer room.

WED. 18 JAN. 1967

Worked on public address system. Checked out B-50 discrepancies. During hook-up of -400V power supply, obtained 115 vac across output and ruined the 200V Technipower units. It is believed to be due in part to the intermittent switch which did not remove AC from the system as it should have when switched off. The recirculate fan was reinstalled. It was also discovered that the outside fan for Van input will not work due to back pressure. Finished wire storage rack; worked in Utility Van. Made initial checks of Potter tape recorders with no major problems. Work on computer progressed.

THURS. 19 JAN. 1967

Print filing and work on Van progressed. Replaced Technipower power supply units in a temporary fashion from spares. Continued work on computer room. Problem was found in the I/O J-Box (PE). B-50 visual null indicator is working okay, but the deflection circuit has a problem. Continued work in Utility Van and computer room.

FRI. 20 JAN. 1967

Mounted elevation angle display in console; worked on CEC recorder in Van. Transferred much equipment and support equipment to the Utility Van. Open sine pot in EL data unit; decided it cannot be repaired here.

SAT. 21 JAN. 1967

Troubleshooting visual null indicator scope; found two high voltage power supplies were inoperative when received. Operated DDH; no major problems are apparent. Reworked DDH drawings to make them more readable. Installed intercom system. Performed general cleanup on the site.

PERKIN-ELMER

MON. 23 JAN. 1967

Worked on portable visicorder; repaired communication connector on the B-50 control console. Investigated pedestal communications; found to be unsatisfactory. Completed troubleshooting of the visual null indicator scope; one was repaired, the other requires a transformer. Worked on DDH drawings.

TUES. 24 JAN. 1967

Found EL position display inoperative due to bad Hi Speed Synchro in pedestal EL data unit. Replaced Synchro transmitter. Found astrodata TTU power supply inoperative; began checkout of servo system. Worked on portable visicorder.

WED. 25 JAN. 1967

Continued servo system checkout; checked and adjusted the DDH system. The TTU power supply appeared to have lost its ground; also, the 400 cycle generator control does not regulate in the remote mode. Removed EL sine pot from pedestal; will be sent to Norwalk, Connecticut, for repair. Started troubleshooting neon driver in TTU. Received more spare parts.

THURS. 26 JAN. 1967

Servo system performance is still being checked out. Inventoried and stored spare parts. Constructed general work bench.

FRI. 27 JAN. 1967

Servo system performance checkout progressed. Installed and checked out communications for dome area and collimator shack. Installed RF box for the signal cable. Work on the DDH progressed.

SAT. 28 JAN. 1967

Checked out servo system. Installed communications in dome and collimator shack. Laid cable for spectral analyzer antenna from Van to tower. Completed work bench and cabinets. Installed another elevation data unit that was found in salvage. Unit appeared to be in good condition.

SUN. 29 JAN. 1967

Continued to check out servo system. Worked on TTU neon driver. Devised wire list for communication to screen room and to Van. Cleaned general site area.

MON. 30 JAN. 1967

New EL data pot appears to be okay. The servo system, DDH, intercom system, and stores are progressing.

TUES. 31 JAN. 1967

Continued to check out servo system. Completed communications in dome area. DDH work is progressing. Tape recorder was put into the portable form and carried to the Press Kwajalein Station to record COBI signal. Checked out the TV and BS cameras. A ramp program from the computer apparently is okay for the servo system.

WED. 1 FEB. 1967

Removed lead weights from the pedestal; mounted the TV camera, boresight camera and its associated cabling. TV camera checked out okay; radiometer work was started. Continued work on computer and servo. A problem with the visual null indicator radar display was discovered.

THURS. 2 FEB. 1967

The pedestal was balanced with the TV and BS cameras in place; the cinespec instrument was simulated with its approximate weight. Cleaned the collimator; lubricated its railbed. Continued work on the radiometer; trouble in the Rad B Chan #1 is prevalent (no pickoff signal). Continued checkout of DDH and servo system; the proper bandpass at 42°/sec has not been met.

FRI. 3 FEB. 1967

Continued checkout of servo system; work on DDH and computer is also progressing. Radiometer trouble is being investigated. Checked out cryogenic package for vacuum loss. Hoist on roof is inoperative. Made a preliminary calibration on the PbS radiometer channels. The BS camera has problems.

SAT. 4 FEB. 1967

Troubleshooting of camera; found buckle trip wire disconnected in DP3-TB2. Cut out floor of dome platform to clear revolving dome. Made removable handle for dome jacks. Removed connection from Rad J-Box (P-28 and P-31) to look for broken or shorted wire apparent in Rad B operation. Found cable shield improperly grounded and corrected this. Continued checkout of DDH, servo system, and computer.

SUN. 5 FEB. 1967

Continued check of servo system. Trouble shooting of TV revealed bad vertical integrator in monitor and was replaced from spares.

MON. 6 FEB. 1967

Servo system work continued; replaced all tubes in the servo velocity loop. Also made preliminary temperature measurements of collimator black body. Performed troubleshooting of time code generator. General cleanup of site.

TUES. 7 FEB. 1967

Began rechecking servo system bandpass after regritting and changing tubes. Checked out DDH and computer. Cleaned Instrument Van preparatory to touch-up painting. Checked out DDH and computer. Servo system now meets frequency in AZ response specification. Finished cleaning the sides of the Van; applied touch-up paint. Fixed time code generator.

WED. 8 FEB. 1967

Ran frequency response on servo velocity loops; conforms to specifications. Continued checkout of DDH and computer. Work started by Aircraft Technicians. Repaired outer skin of Instrument Van damaged in shipping. Applied touch-up paint to Instrument Van. Repaired Instrument Van doors, latches, and RFI fingers. Boresight pedestal, TV, and boresight camera: Unable to boresight radiometers (problems with hardware).

THURS. 9 FEB. 1967

Worked on servo radar loop using computer. Worked on radiometer and on BS camera fiducial circuit. Made repairs to skin of Instrument Van. Installed new hardware on floor boards. Checked out DDH and computer.

FRI. 10 FEB. 1967

Worked on servo radar loop checkout. Worked on radiometers. Repaired camera cable. Performed peripheral tasks. Surveyor here to check on survey of site; will begin Monday night. Worked on property tagging and inventory.

SAT. 11 FEB. 1967

Worked on servo radar loop; problems either in radar loop or computer program. Found fiducial lamp assembly in BS camera open. New fiducial plate from spares has no lamps; sent back to Norwalk, Connecticut, to have lamps installed. Continued on property tagging and listings. Boresight camera: not finalized.

MON. 13 FEB. 1967

Worked on servo radar (COBI) loop; is tracking properly now (was necessary to change compensation). Installed baffler in air conditioning (Van) ducts; cleaned air conditioner. Surveyor on station: Worked on DDH problems.

TUES. 14 FEB. 1967

Worked on servo and DDH checkout. Peripheral items being worked on. Surveyor still here.

WED. 15 FEB. 1967

Checked out computer, DDH, and servo. Continued work on peripheral items. Surveyor still on site.

THURS. 16 FEB. 1967

Checked out and debugged the system - specifically computer, DDH, and servo. Problem in D to A converter corrected. Worked on radiometer circuits.

FRI. 17 FEB. 1967

Checked out and debugged the system. Continued work on peripheral items.

SAT. 18 FEB. 1967

Power off all day.

SUN. 19 FEB. 1967

Kellers worked 2 hours on inventory.

MON. 20 FEB. 1967

Checked out the system. Continued work on peripheral items.

TUES. 21 FEB. 1967

Checked out the system. Began work on computer program checkout. Worked on obtaining proper hookup to computer for tape dump.

WED. 22 FEB. 1967

Continued checkout of the system. Continued work on peripheral items. Working on computer program.

THURS. 23 FEB. 1967

Continued checkout of the system. Work on computer program continues. Completed hookup and made tape dump with computer.

FRI. 24 FEB. 1967

Continued checkout of the system. Continued work on peripheral items. Computer checkout continues. Made new COBI tape.

SAT. 25 FEB. 1967

Checked out the system. Trouble in DDH being checked. Continued work on peripheral items. Checked out the computer.

SUN. 26 FEB. 1967

Checked out the system. Worked on servo test circuit. Continued work on peripheral items.

MON. 27 FEB. 1967

Troubleshooting DDH. Checked out the servo test circuit. Continued work on peripheral items. Checked out the computer.

TUES. 28 FEB. 1967

Troubleshooting DDH and I/O interface. Checked out the computer and the jitter package. Continued work on peripheral items. Wired dome position synchro.

WED. 1 MAR. 1967

Troubleshooting DDH. Continued checkout of computer program. Checked out the jitter package. Began wiring of range interface. Continued work on peripheral items. Work started on generator shelter and wiring.

THURS. 2 MAR. 1967

Troubleshooting DDH. Continued checkout and debugging of computer program. Continued work on peripheral items. Continued wiring of range interface. Received second cooling finger for radiometer InSb detector. Cleared trouble in DDH. Ran performance curves on dome servo. Continued work on generator shelter and wiring.

FRI. 3 MAR. 1967

Encountered more trouble in DDH. Performed troubleshooting and checkout. Continued checkout of computer program. Continued work on peripheral items. Sent 10 inch parabola back to Norwalk, Connecticut; found broken line on A/C compressor in Utility Van. Put in Work Order for repair and recharge.

SAT. 4 MAR. 1967

Worked on DDH, computer program, and peripheral tasks. Repaired air conditioning in van. Worked on 400 V converter shelter. Work started by WECO on range signal cable.

SUN. 5 MAR. 1967

Finished wiring in 2A5 for COBI recording and switching. Cleaned up the site. Worked on computer program.

MON. 6 MAR. 1967

Troubleshooting DDH. Worked on computer program. Continued work on peripheral items. Continued construction of converter shed.

TUES. 7 MAR. 1967

Had DDH working and ran servo system in COBI loop using a parabolic function; works okay. Continued work on peripheral items. Troubleshooting camera timing neon driver. Continued work on converter shed. Worked on computer program.

WED. 8 MAR. 1967

Worked on DDH and computer program. Made some servo tests in computer loop. Worked on radiometer cooling (getting orifice drilled to proper size, etc.). Worked on camera timing. Continued work on peripheral items.

THURS. 9 MAR. 1967

Continued checkout of DDH, computer, and servo. Continued work on peripheral items. Finished frequency converter shelter. Received RF filters for range signal lines. Performed calibration run on radiometers. Part of calibration on magnetic tape. Tape unit malfunctioned.

FRI. 10 MAR. 1967

Continued checkout of computer, DDH, and servo. Work on range signal cable installation by WECO. Continued work on peripheral items. Installed hoist motor on roof. Temperature measurement being made in 2A12.

SAT. 11 MAR. 1967

Checked out computer, servo, and DDH. Continued tasks on peripheral items. Began wiring for moving converter. Worked on radiometer calibration calculations. Finished installation of range signal cable and filters. Checked COBI signal for level and noise.

SUN. 12 MAR. 1967

Worked on radiometer calibration data and on timing for camera.

MON. 13 MAR. 1967

Worked on CEC recorder; performed troubleshooting timing in DDH. Moved frequency converter to outside shelter and finished wiring. Replaced broken brush in generator armature.

TUES. 14 MAR. 1967

Worked on SDS tape unit; now okay. Continued checkout of servo, DDH, and computer. Continued work on peripheral items. Set AZ encoder for 90 degrees at north. Ran stop test on boresight camera. Installed wiring for Range time Press time and COBI data into screen room - checks okay.

WED. 15 MAR. 1967

Worked on DDH, computer, and servo checkout. Continued work on peripheral items. Checked out InSb detectors in radiometers - check below sensitivity.

THURS. 16 MAR. 1967

Checked out computer, DDH, and servo. Checked new InSb detector - okay. Ran calibration on PbS detectors - recorded on visicorder and magnetic tape. Continued work on peripheral items.

FRI. 17 MAR. 1967

Continued systems check and optimization. Repaired timing problems. Continued work on peripheral items. Vidicon camera not working.

SAT. 18 MAR. 1967

Continued systems checkout and optimization. Troubleshooting vidicon camera. Continued work on peripheral items. Worked on property inventory.

SUN. 19 MAR. 1967

Fixed vidicon system. Worked on property inventory. Painted and waxed the floors.

MON. 20 MAR. 1967

Boresighted all instruments except the BS camera. Ran calibration on the InSb detectors. Ran field of view on all detectors. Worked on vidicon system. Checked out computer, DDH, and servo system.

TUES. 21 MAR. 1967

Installed and checked out phone in Van. Wiring and end installation installed for Project net and OAS net. Worked on radiometer calibration data. Checked out computer programs - servo and system checks.

WED. 22 MAR. 1967

Worked on computer programs - servo, DDH, and computer system checks. Ran field of view plots on radiometer detectors. Continued work on peripheral items.

THURS. 23 MAR. 1967

Worked on computer program, servo test, and DDH. Finished photographs of installation. Completed wiring for Range interface. Work on peripheral items almost finished.

FRI. 24 MAR. 1967

Ran new field trace on radiometer detectors. Worked on servo recordings - computer programs and DDH. Typed reports, inventories, and DD-250 forms.

SAT. 25 MAR. 1967

Continued work with computer and servo loop: Recording functions, etc. Continued work on peripheral items. Worked on radiometer InSb detector - may have lost vacuum in detector assembly.

PERKIN-ELMER

SUN. 26 MAR. 1967

Worked with computer programs and on B-50 servo loop. Repaired damage to B-50 circuit caused by water.

MON. 27 MAR. 1967

Finished computer program. Worked on servo system. Repaired trouble in mode switches. Installed phone in screen room. Installed line driver on range input signals. Worked on reports. Continued typing in preparation for system acceptance.

TUES. 28 MAR. 1967

Started acceptance test. Made servo and computer demonstrations. Started property inventory with General Electric property personnel.

WED. 29 MAR. 1967

Continued acceptance test. Made servo, computer, dome, radiometers, collimator, TV, and boresight camera demonstration. Continued inventory.

THURS. 30 MAR. 1967

Continued acceptance test. Made servo, computer, and complete system demonstration. Continued inventory.

FRI. 31 MAR. 1967

Finished acceptance test. Demonstrated B-50 station and mount pointing accuracy in COBI loop. Continued inventory.

SAT. 1 APRIL 1967

Continued inventory. Paper work for property transfer almost complete. Started packing material for return to Norwalk, Connecticut. Assisted General Electric in learning system operation.

SUN. 2 APRIL 1967

Continued work on inventory and property transfer.

MON. 3 APRIL 1967 (Last entry)

Helped General Electric get ready for operation. Completed property transfer. Operation is cancelled.

APPENDIX B

LOCAL CLIMATOLOGICAL DATA, KWAJALEIN, MARSHALL ISLANDS, PACIFIC, 1966

LOCAL CLIMATOLOGICAL DATA
ANNUAL SUMMARY WITH COMPARATIVE DATA, 1966

KWAJALEIN, MARSHALL ISLANDS, PACIFIC

NARRATIVE CLIMATOLOGICAL SUMMARY

Kwajalein, a small coral atoll located less than 700 miles north of the equator, is 3 miles in length and 1/2-mile wide. The land surface of the Island, which has very little effect on the climate of the locality, has an average elevation of less than 10 feet m.s.l. Highest points of the Island are 12-15 feet m.s.l.

Kwajalein has a tropical marine climate characterized by (1) relatively high annual rainfall; and (2) warm to hot, humid weather throughout the year.

Temperatures are very equable from day to day and month to month. Because of the low latitude, there are only slight seasonal variations in the length of daylight period and the altitude of the sun at Kwajalein. As a result, the variation of the amount of solar energy received is small. The small variation in solar energy and the marine influence are the principal reasons for the uniform temperatures in the area. The range of normal temperature between the coldest month and the warmest month averages about 2.0° F., and the average daily temperature range is less than 10°. Maxima occur in the early afternoon and minima occur with showers at any time of day, or in the early morning if there are no showers.

The principal rainfall season extends from mid-May to mid-December. On the average, about 75 percent of the annual rainfall is recorded during this period. November is usually the wettest month. Light, easterly winds, almost constant cloudiness, and frequent moderate to heavy showers prevail during the wet season.

The dry season includes the period mid-December to mid-May, and is characterized not so much by lack of showers as by light showers of short duration. In this season the trade winds are persistent, blowing from the northeast 15-20 knots almost continuously. Cloudiness is at a minimum, and the sky is less than one-half covered most of the time; but clear skies are rare.

Severe storms with attendant damaging winds are rare in the vicinity of Kwajalein. During the wet season, however, small, weak depressions may form near the Island. Some of these intensify and a few eventually develop into typhoons after moving westward away from the island. These depressions cause heavy rainfall in the Kwajalein atoll.

The relative humidity is uniformly high throughout the year, and is slightly higher in the wet season than in the dry season. The combination of high humidity and proximity of the salt water ocean presents a corrosion problem.

U.S. DEPARTMENT OF COMMERCE
JOHN T. CONNOR, Secretary
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
ROBERT M. WHITE, Administrator
ENVIRONMENTAL DATA SERVICE

LATITUDE 8° 44' N
LONGITUDE 167° 44' E
ELEVATION (ground) 8 Feet

METEOROLOGICAL DATA FOR THE CURRENT YEAR

KWAJALEIN, MARSHALL ISLANDS, PACIFIC
AIRPORT STATION
1966

Month	Temperature: Averages: Daily maximum	Daily minimum	Monthly	Extremes: Highest	Date	Lowest	Date	Degree days	Precipitation: Total	Greatest in 24 hrs.	Date	Snow, Sleet: Total	Greatest in 24 hrs.	Date
JAN	85.5	75.9	80.7	87	31+	71	24	0	2.97	0.79	12	0.0	0.0	
FEB	85.9	76.7	81.8	88	27+	74	28+	0	0.40	0.15	26	0.0	0.0	
MAR	87.2	75.9	82.1	90	10	73	22	0	4.00	2.40	14-15	0.0	0.0	
APR	85.8	76.7	81.3	88	29	73	10+	0	11.65	3.51	5-6	0.0	0.0	
MAY	86.5	76.5	81.6	89	28+	74	10+	0	13.72	2.42	2-3	0.0	0.0	
JUN	86.5	76.7	81.6	90	29	74	19+	0	10.42	2.47	9-10	0.0	0.0	
JUL	87.3	77.5	82.4	89	1	74	16	0	7.38	1.65	12-13	0.0	0.0	
AUG	88.0	76.8	82.4	92	22+	74	6+	0	15.03	2.75	5-6	0.0	0.0	
SEP	88.4	77.7	83.1	92	4	74	9	0	12.55	3.65	18	0.0	0.0	
OCT	87.5	77.6	82.6	90	28+	73	5	0	7.80	1.36	9-10	0.0	0.0	
NOV	86.7	77.2	82.0	90	11	73	27+	0	9.19	3.31	31-1	0.0	0.0	
DEC	85.2	75.3	80.3	87	28+	72	2	0	21.08	3.91	4-5	0.0	0.0	
YEAR	86.8	76.8	81.8	92	SEP. 4	71	JAN. 24	0	116.19	3.91	DEC. 4-5	0.0	0.0	

Month	Relative humidity: Midnight LST	6:00 A.M. LST	Noon LST	6:00 P.M. LST	Wind &: Resultant: Direction	Speed	Average speed	Fastest mile: Speed	Direction	Date	Percent of possible sunshine	Average sky cover sunrise to sunset	Number of days: Sunrise to sunset: Clear	Partly cloudy	Cloudy	Precipitation .01 inch or more	Snow, Sleet 1.0 inch or more	Thunderstorms	Heavy fog	Temperatures: Maximum: 90 and above	32 and below	Minimum: 32 and below	0 and below
JAN	80	81	73	76	06	19.5	18.9	30	5	12		8.5	0	10	21	17	0	0	0	0	0	0	0
FEB	78	79	67	71	06	18.2	18.5	30	6	28		7.6	2	11	15	8	0	0	0	0	0	0	0
MAR	81	81	72	76	06	17.8	18.1	37	6	25		9.5	0	3	28	13	0	0	0	1	0	0	0
APR	84	84	77	81	07	16.8	17.7	30	7	17		9.2	1	2	27	18	0	0	0	0	0	0	0
MAY	87	87	78	83	07	13.6	14.1	25	8	14+		8.5	1	6	24	25	0	0	0	0	0	0	0
JUN	86	86	79	82	07	11.1	12.6	28	9	21		8.6	0	6	24	23	0	0	0	1	0	0	0
JUL	85	85	77	81	08	7.8	9.3	37	9	15		8.4	1	8	22	23	0	0	0	0	0	0	0
AUG	84	85	77	78	08	3.6	5.9	23	21	26		7.5	1	14	15	27	0	3	0	2	0	0	0
SEP	83	82	74	78	11	1.6	7.1	25	18	18+		8.5	0	7	23	24	0	1	0	4	0	0	0
OCT	81	82	76	78	11	5.2	10.5	37	15	5		8.7	1	5	25	23	0	3	0	2	0	0	0
NOV	81	83	77	78	07	9.7	12.0	37	5	22		8.9	0	6	24	25	0	1	0	1	0	0	0
DEC	84	84	79	82	07	17.6	19.0	37	9	11		8.8	1	4	26	23	0	0	0	0	0	0	0
YEAR	83	83	76	79	07	11.6	13.6	37	9	DEC. 11+		8.6	8	82	275	250	0	8	0	11	0	0	0

NORMALS, MEANS, AND EXTREMES

Month	Temperature: Normal: Daily maximum	Daily minimum	Monthly	Extremes: Record highest	Year	Record lowest	Year	Normal degree days	Precipitation: Normal total	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs. ø	Year	Snow, Sleet: Mean total	Maximum monthly	Year	Maximum in 24 hrs.	Year
(a)	(b)	(b)	(b)	14		14		(b)	(b)	22		22		6		22	22		22	
J	82.2	78.0	80.1	91	1953	71	1966+		3.61	15.65	1951	0.90	1964	4.05	1963	0.0	0.0		0.0	
F	82.0	78.0	80.0	92	1954	71	1963		2.19	6.32	1963	0.40	1966	3.37	1963	0.0	0.0		0.0	
M	82.7	78.2	80.5	91	1954+	72	1963+		6.45	24.35	1951	0.18	1945	2.40	1966	0.0	0.0		0.0	
A	83.2	78.4	80.8	92	1953	71	1964		5.02	14.13	1964	0.24	1965	4.11	1964	0.0	0.0		0.0	
M	83.7	78.4	81.1	93	1953	72	1964+		8.18	24.18	1964	1.35	1953	4.58	1964	0.0	0.0		0.0	
J	84.4	78.3	81.4	92	1958	71	1964		9.63	19.61	1955	4.96	1953	2.73	1964	0.0	0.0		0.0	
J	85.2	77.9	81.6	94	1953	70	1954		8.91	17.33	1958	4.84	1957	3.69	1964	0.0	0.0		0.0	
A	85.9	77.8	81.9	95	1958	71	1957+		9.59	16.95	1948	5.83	1952	3.37	1963	0.0	0.0		0.0	
S	86.1	77.7	81.9	93	1958	72	1964		10.19	19.76	1964	5.32	1965	3.65	1966	0.0	0.0		0.0	
O	85.9	77.9	81.9	97	1958	72	1964+		10.88	20.05	1964	5.77	1946	3.89	1964	0.0	0.0		0.0	
N	84.5	78.1	81.3	92	1953	71	1965		12.13	19.51	1957	4.40	1945	3.31	1966	0.0	0.0		0.0	
D	83.2	78.3	80.8	90	1955+	69	1963		8.96	30.38	1950	2.90	1957	6.68	1963	0.0	0.0		0.0	
YR	84.1	78.1	81.1	97	OCT. 1958	69	DEC. 1963		94.76	30.38	DEC. 1950	0.18	MAR. 1965	6.68	DEC. 1963	0.0	0.0		0.0	

Month	Relative humidity: Midnight LST	6:00 A.M. LST	Noon LST	6:00 P.M. LST	Wind: Mean hourly speed	Prevailing direction	Fastest mile: Speed	Direction	Year	Pct. of possible sunshine	Mean sky cover sunrise to sunset	Mean number of days: Sunrise to sunset: Clear	Partly cloudy	Cloudy	Precipitation .01 inch or more	Snow, Sleet 1.0 inch or more	Thunderstorms	Heavy fog	Temperatures: Max.: 90 and above	32 and below	Min.: 32 and below	0 and below
(a)	6	6	6	6	6	3					6	6	6	6	14	14	6	6	14	14	14	14
J	79	80	71	76	18.5	ENE					7.4	4	10	17	15	0	*	0	*	0	0	0
F	80	80	71	75	18.3	ENE					7.2	4	9	15	14	0	*	0	1	0	0	0
M	80	80	69	75	17.4	ENE					7.6	4	9	18	14	0	*	0	1	0	0	0
A	83	84	75	78	15.6	ENE					8.2	2	7	21	17	0	0	0	1	0	0	0
M	86	85	79	81	14.4	ENE					8.3	1	7	23	22	0	1	0	2	0	0	0
J	85	85	78	81	12.2	ENE					8.1	2	7	21	23	0	1	0	1	0	0	0
J	85	86	78	81	10.6	E					8.5	1	7	23	24	0	2	0	3	0	0	0
A	85	84	78	81	9.1	ENE					8.0	1	10	20	24	0	2	0	4	0	0	0
S	84	84	78	81	9.0	E					8.4	1	6	23	23	0	1	0	5	0	0	0
O	83	84	77	80	9.7	E					8.5	1	6	24	23	0	2	0	4	0	0	0
N	83	84	78	80	12.6	ENE					8.7	1	5	24	23	0	1	0	1	0	0	0
D	83	83	76	80	17.4	ENE					8.4	2	6	23	19	0	1	0	*	0	0	0
YR	83	83	76	79	13.7	ENE					8.1	24	89	252	241	0	10	0	24	0	0	0

ø Data for July - December 1960 considered in extracting maximum-in-24 hours precipitation.

(a) Length of record, years.
(b) Climatological standard normals (1931-1960).
* Less than one half.
\+ Also on earlier dates, months or years.
T Trace, an amount too small to measure.
Below-zero temperatures are preceded by a minus sign.
The prevailing direction for wind in the Normals, Means, and Extremes table is from records through 1963.

Unless otherwise indicated, dimensional units used in this bulletin are: temperature in degrees F.; precipitation, including snowfall, in inches; wind movement in miles per hour; and relative humidity in percent. Degree day totals are the sums of the negative departures of average daily temperatures from 65° F. Sleet was included in snowfall totals beginning with July 1948. Heavy fog reduces visibility to 1/4 mile or less.

Sky cover is expressed in a range of 0 for no clouds or obscuring phenomena to 10 for complete sky cover. The number of clear days is based on average cloudiness 0-3; partly cloudy days 4-7; and cloudy days 8-10 tenths.

& Figures instead of letters in a direction column indicate direction in tens of degrees from true North; i.e., 09 - East, 18 - South, 27 - West, 36 - North, and 00 - Calm. Resultant wind is the vector sum of wind directions and speeds divided by the number of observations. If figures appear in the direction column under "Fastest mile" the corresponding speeds are fastest observed 1-minute values.

AVERAGE TEMPERATURE

Year	Jan.	Feb	Mar	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Annual
1946	81.4	81.[illegible]	82.7	82.5	83.9		83.0	81.9	81.9	82.8	83.5	82.8	
1947	82.3	83.0		83.9	83.1	83.2	82.7	82.4	81.6	81.9	82.9	83.0	
1948	82.4	81.9	81.7	83.1	83.1	83.3	83.4	82.8	82.9	83.5	82.4	81.5	82.7
1949	81.6	82.1	82.5	82.7	82.5	82.6	82.9	82.5	82.0	81.7	81.7	81.2	82.2
1950	81.[illegible]	81.1	82.6	82.0	82.9	82.9	82.0	82.3	81.9	81.7	83.2	82.4	82.2
1951	82.4	82.7	80.6	82.7	83.1	[illegible]	82.8	83.2	84.2	83.7	83.5	83.5	82.9
1952	81.9	82.8	83.9	84.9	83.1	83.7	83.7	84.2	84.2	83.1	83.1	82.7	83.4
1953	83.1	83.1	83.2	84.0	84.9	83.8	83.4	83.0	83.7	84.6	82.6	82.8	83.5
1954	82.6	83.4	83.4	83.1	82.1	83.1	83.1	83.0	83.1	82.8	81.2	81.1	82.7
1955	81.0	80.7	80.1	80.3	80.2	80.9	82.0	82.6	82.4	81.6	81.3	81.4	81.2
1956	80.1	80.3	80.4	81.3	81.5	81.4	82.5	82.5	82.5	82.4	82.6	82.1	81.6
1957	81.0	80.6	81.9	81.5	81.9	81.8	83.0	83.2	82.7	83.3	81.7	81.6	82.0
1958	80.8	81.2	81.4	[illegible]	82.2	81.7	82.3	83.6	84.7	84.3	82.7	82.5	82.4
1959	80.9	80.0	80.9	80.8	82.2	82.9	83.4	84.2	82.9	82.9	81.3	81.2	82.0
1960	80.3	80.7	81.5	80.4	81.3	81.6	81.7	81.8	82.1	82.0	81.0	82.1	81.4
1961	81.5	82.1	82.1	82.1	81.1	81.7	81.3	81.4	81.2	81.7	81.1	80.8	81.4
1962	81.3	81.6	82.1	81.9	81.2	81.7	81.4	81.7	81.3	82.1	81.0	82.1	81.6
1963	82.7	81.2	81.8	82.3	82.6	82.1	81.6	82.0	82.8	81.7	82.1	81.0	81.9
1964	83.8	80.8	81.5	80.7	81.0	81.5	81.1	81.0	80.5	80.6	80.7	80.4	80.9
1965	80.[illegible]	81.0	82.6	82.8	82.2	81.1	80.9	81.9	82.[illegible]	81.9	80.9	81.3	81.6
1966	80.7	81.5	82.1	81.3	81.6	81.6	82.4	82.4	83.1	82.6	82.0	80.3	81.8
RECORD MEAN	81.4	81.5	81.9	82.1	82.2	82.2	82.4	82.6	82.7	82.5	81.9	81.7	82.1
MAX	85.2	85.4	85.9	86.0	86.3	86.5	87.0	87.4	87.5	87.2	86.1	85.5	86.3
MIN	77.6	77.6	77.8	78.1	78.0	77.9	77.7	77.8	77.8	77.8	77.6	77.8	77.8

TOTAL DEGREE DAYS

Season	July	Aug.	Sept	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total

TOTAL PRECIPITATION

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1945	2.49	2.05	4.63	5.60	9.40	9.75	9.48	6.45	6.66	7.44	4.40	8.26	76.61
1946	3.06	1.26	8.21	9.19	4.77	7.70	5.25	7.25	8.30	5.77	10.22	5.53	76.51
1947	1.99	1.59	8.64	2.24	8.33	7.10	12.35	10.87	14.29	11.08	11.82	11.95	102.25
1948	1.16	0.88	6.34	1.84	6.53	12.72	6.17	16.95	11.67	11.81	16.76	11.58	104.41
1949	1.89	3.14	3.29	0.91	4.25	7.98	7.44	8.63	11.62	16.27	14.03	8.18	87.63
1950	2.89	2.66	8.98	8.34	11.52	6.50	13.50	15.19	19.01	19.20	10.96	30.38	149.13
1951	15.66	5.13	24.33	6.08	7.79	10.10	12.52	9.24	10.21	12.40	10.92	5.38	129.76
1952	5.09	0.61	1.21	1.35	15.60	5.58	8.75	5.83	10.14	18.37	9.82	15.32	97.67
1953	1.47	0.77	3.35	4.25	1.35	4.96	7.71	15.41	9.45	8.77	15.62	11.52	84.63
1954	1.76	1.07	3.38	11.35	15.46	14.00	8.79	14.33	10.76	15.09	8.67	10.99	115.66
1955	3.17	1.34	19.02	5.82	15.42	19.61	9.76	6.46	8.56	12.88	10.59	6.02	118.65
1956	4.36	1.52	9.42	6.00	11.63	11.45	9.13	10.37	8.57	[illegible]	9.42	3.91	95.38
1957	4.49	5.95	0.81	1.18	10.99	6.29	4.84	7.08	11.14	7.27	19.51	2.90	82.45
1958	6.74	1.07	1.93	5.72	6.28	9.45	17.33	7.77	5.51	12.20	9.01	7.92	90.93
1959	1.15	4.87	1.93	6.21	4.27	7.52	8.79	7.50	12.41	8.33	19.26	6.48	88.72
1960	[illegible]	1.13	6.13	10.69	6.98	[illegible]	8.55	12.25	11.89	9.00	19.20	3.67	102.00
1961	3.29	1.95	4.32	4.85	13.71	7.84	9.98	10.60	15.53	10.29	13.61	8.50	104.47
1962	3.50	4.84	3.88	5.76	12.49	5.75	10.67	7.26	11.75	7.79	14.17	4.68	92.54
1963	6.22	6.32	4.56	5.02	7.47	13.76	9.80	15.09	[illegible]	19.56	8.61	14.11	116.63
1964	0.90	3.07	3.44	14.13	24.18	9.59	10.67	11.71	19.76	20.05	9.27	12.60	139.37
1965	3.85	1.01	0.18	0.24	3.20	12.55	12.03	8.09	5.32	9.95	9.17	4.49	70.04
1966	2.97	0.40	4.00	11.65	13.72	10.42	7.38	15.03	12.55	7.80	9.19	21.08	116.19
RECORD MEAN	3.61	2.39	6.00	5.84	9.79	9.63	9.59	10.42	10.94	11.87	12.02	9.79	101.89

TOTAL SNOWFALL

Season	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total

Record mean values above (not adjusted for instrument location changes listed in the Station Location table) are means for the period beginning in 1948 for temperature and 1945 for precipitation.

STATION LOCATION

Location	Occupied from	Occupied to	Airline distance and direction from previous location	Latitude North	Longitude East	Elevation above: Sea level: Ground at temperature site	Elevation above: Ground: Wind instruments	Extreme thermometers	Psychrometer	Telepsychrometer	Tipping bucket rain gage	Weighing rain gage	8" rain gage	Hygrothermometer	Pyrheliometer	Remarks
U. S. Army	2-17-41	4-15-52		8° 43'	167° 44'	7	-	-	-				-			
U. S. Navy	4-15-52	11- 2-54	Unknown	8° 44'	167° 43'	7	-	-	-				-			
U. S. Navy	11- 3-54	6-30-60	1-1/4 mi.NE	8° 41'	167° 44'	10	62	-	26				22			
U. S. Weather Bureau	7-1-60	Present	3/4 mi.SW	8° 44'	167° 44'	8	75	5	4		a2		2			a - Added 6-13-64.

Requests for additional information should be directed to the Weather Bureau Office for which this summary was issued.

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